

EVALUATION OF PERENNIAL (RHIZOMA) PEANUT FORAGE
AS A FEED FOR GESTATING SWINE

BY

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I Dedicate this Dissertation to My Parents

Carmen Sales de Lopez and Vicente Lopez

To My Wife Blanca Luz

and To My Daughters

Carla Maria, Gabriela and Daniela Nicole

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Five experiments were conducted to evaluate the use of ground perennial peanut hay (PPH) in sow gestation diets. Diets containing 0%, 40%, 60% or 80% PPH were fed at a level which provided 127.0 kcal/kg BW^{.75}/day in metabolizable energy (ME). Feeding 0%, 40%, 60%, and 80% PPH (experiment 1) or 0% and 80% PPH (experiments 2 and 3) had no effect on litter size and piglets alive from birth to 21 days postpartum. In experiment 1, sows fed 80% PPH produced piglets with lower ($P < .05$) weights at birth and at 7 and 14 days of age. However, piglet weights at 21 days and net weight gain of weaned piglets from sows fed 0% and 80% PPH did not differ. Feeding sows 80% PPH had no effect on piglet birth weight, and piglet weights at 7, 14 and 21 days postpartum, or net weight gain of weaned piglets for any parity in experiment 2 or experiment 3. Sow weights at

breeding, 110 days postcoitum, 24 hr postpartum and 21 days postpartum were lower ($P<.05$) for sows fed 80% PPH. Consequently, gestation weight gain and weight change for sows fed 80% PPH were lower ($P<.05$). Colostrum fat percentage was increased ($P<.05$) while lactose was decreased ($P<.05$) among sows fed 80% PPH. In experiment 4, 0% or 80% PPH had no effect on digestible energy (DE) intake. However, DE% and ME% were lower ($P<.0001$) for 80% PPH. Sows fed 80% PPH had higher ($P<.0001$) nitrogen (N) intake but lower ($P<.03$) digestible and retained N than those fed 0% PPH. Digestible and retained N expressed as a percentage of N intake were lower ($P<.03$) for 80% PPH. No treatment differences were found in the quantities of dry matter and hemicellulose digested. However, sows fed 80% PPH digested a larger ($P<.0002$) quantity of neutral detergent fiber, acid detergent fiber, cellulose and lignin than those fed 0% PPH. In experiment 5, 0% or 80% PPH had no effect on the overall plasma mean concentrations of glucose, protein, urea nitrogen, total cholesterol, LDL-cholesterol, and triglycerides. The 80% PPH effected higher ($P<.008$) concentrations of lactic acid and lower HDL-cholesterol ($P<.05$) in plasma than 0% PPH. Results of this study suggest that levels up to 80% PPH may be fed to sows in second or greater parity without affecting piglet number and piglet net weight gain from birth to 21 days postpartum.

CHAPTER 1 INTRODUCTION

Carbohydrates from cereal grains are the most abundant energy source in swine diets. In Florida, however, cereal grains such as corn and grain sorghum are not produced in adequate quantities to meet the demand of the swine industry. Feed constitutes 70 to 80% of all costs in swine production and a large proportion of grain used in feed must be imported. Therefore, research to identify alternative feedstuffs is needed. Among the alternatives to corn:soybean meal diets fed to gestating sows is the use of high fiber diets from pasture forages to meet part of the nutrient requirements for reproduction.

Utilization of nutrients from dietary fiber by growing-finishing swine has been shown to be minimal (Bohman et al., 1953, 1955; Hanson et al., 1956; Becker et al., 1956; Heitman and Meyer, 1959; Kornegay, 1978; Kass et al., 1980a; Powley et al., 1981; Frank et al., 1983; Lindemann et al., 1986; Pond et al., 1989). In previous studies, high fiber, low energy diets fed to sows during gestation did not affect reproductive performance (Danielson and Noonan, 1975; Pollman et al., 1980; Calvert et al., 1985; Pond et al.,

1985; Holzgraefe et al., 1986). Feeding alfalfa to gravid sows has been reported to increase the number of piglets farrowed, and improve piglet survival and weight at weaning (Teague, 1955; Seerley and Wahlstrom, 1965). Literature does not contain an abundant amount of information concerning the effects of feeding gestation high fiber diets on milk composition and on blood metabolites during gestation.

Perennial peanut, a forage legume that is adapted to the climate and soils of Florida, has promise as a feed for gestating swine. Therefore, the objectives of this research project were as follows:

1. To determine through a titration study the maximum level at which ground perennial peanut hay could be added to sow gestation diets without affecting reproductive performance.
2. To determine the long-term effects of feeding high levels of perennial peanut hay during three successive gestations on maternal weight gains, litter size and number and weight of live piglets from birth to 21 days postpartum.
3. To compare percentages of total solids, fat, protein, lactose, ash and caloric value of colostrum at day 1 and milk at day 7 of lactation when sows were fed a standard corn:soybean meal gestation diet or a diet containing perennial peanut hay during gestation.

4. To determine the effect of feeding 0% or 80% perennial peanut hay diets during gestation on the utilization of dietary nitrogen, energy, ether extract and the fiber constituents; NDF, ADF, hemicellulose, cellulose, and lignin.
5. To evaluate the effects of feeding a diet containing 0% or 80% perennial peanut hay to sows during gestation on plasma concentrations of glucose, protein, urea nitrogen, lactic acid, total cholesterol, high density lipoprotein cholesterol, low density lipoprotein cholesterol and triglycerides.

CHAPTER 2 LITERATURE REVIEW

Forages For Sows During Gestation

...Behold, I have given you every herb bearing seed, which is upon the face of all the earth, and every tree, the fruit of a tree yielding seed; to you it shall be for meat. And to every beast of the earth, and to every fowl of the air, and to everything that creepeth upon the earth, wherein there is life, I have given every green herb for meat (Holy Bible, Genesis 1:29,30).

The objective of this literature review is to collect and report the body of published data concerning the effects of high fiber diets on gestating swine. Since experimental designs have varied greatly among researchers, and with passage of time, no attempt is made to interpret these data or the protocols of other researchers referenced herein.

Prior to 1960, pasture was considered essential in meeting the nutritional requirements of swine, particularly with respect to reproductive performance (Ballinger, 1939, 1944; Krider et al., 1946; De Pape et al., 1953; Terrill et al., 1953; Conrad and Beeson, 1954, 1955; Teague, 1955; Johnson et al., 1957; Eyles, 1959).

Conrad and Beeson (1955) stated that sows have a tremendous digestive capacity, the extent of which has not been completely understood. Furthermore, they reported sows that were self-fed during gestation were able to consume 4.5

to 6.4 kg of a bulky ration per head daily. These observations are in agreement with those of Ballinger (1939), and of Conrad and Beeson (1954).

Good pasture is nutritious to pregnant sows because often they can be maintained on grazing alone or the combination of pasture with only minimal energy and protein supplements. Ballinger (1939) found that sows can eat between 9.1 and 11.4 kg fresh forage per head daily. He suggested that the small live weight gains of pregnant sows fed on pasture alone was evidence that an all-grass diet was barely equivalent in nutrients to a maintenance ration.

If the conversion factor (7.0 kg fresh forage = 1.0 kg meal) is applied to 9.1 to 11.4 kg fresh forage, sows in Ballinger's experiment (Ballinger, 1939) were fed an equivalent of 1.3 to 1.6 kg of meal (Eyles, 1959).

Mitchell et al. (1931), cited by Johnson et al. (1957), demonstrated that the feed demands of the pregnant sow for embryonic growth and other products of conception are largely protein and mineral matter. They also observed that the extra food demands for fetal growth are confined largely to the last half, or last third, of the gestation period. This finding is supported by Ballinger (1944) who showed that grazing sows fed 2.3 kg of meal per head per day during the last six weeks of pregnancy produced piglets with a higher mean birth weight than those farrowed by sows fed during pregnancy on pasture alone.

The swine producer does not strive for maximum gains from sows during gestation, hence the energy requirements for body weight gain are less for the pregnant sow than for the growing finishing pig. This fact would suggest that a considerable amount of feed can be saved during gestation by the use of a good quality pasture. Sows grazing good quality legume pasture can meet more than half their nutrient requirements for reproduction (Wiley, 1919).

Foster (1973) reported that when good pasture is used to feed pregnant sows, the nutrients that are slightly deficient include energy, phosphorous, salt, and vitamin B₁₂; and that protein may be borderline. Foster's observations suggested that for maximum reproductive performance of pregnant sows on pasture, supplementing a small quantity of corn, protein and mineral salts was desired.

Effects of Fiber vs Grain on Reproductive Performance

Krider et al. (1946) found that a basal diet composed of ground yellow corn, expeller soybean meal, 5% dehydrated alfalfa meal, and fortified cod-liver oil, was nutritionally inadequate for gestation and lactation under drylot conditions. Furthermore, they reported that sows fed the basal diet weaned only 26% of their piglets, averaging 7.8 kg per piglet at 56 days of age. In the same experiment, sows fed the basal diet plus rye pasture weaned 74% of their piglets with an average weaning weight of 14.5 kg each.

In primiparous sows (Terrill et al., 1953), number of piglets farrowed per litter, and percentage survival of piglets at one week of age were increased by the addition of 1.1 kg shelled corn daily to a ration composed mainly of ladino clover plus free access to minerals.

Good reproductive performance has been reported by feeding alfalfa to pregnant sows (De Pape et al., 1953; Teague, 1955). During this period of time and before the advent of synthetic vitamins it was a common practice to include 15% or more alfalfa in the breeding and gestation diets fed to swine.

Teague (1955) studied the effect of alfalfa on ovulation rate in primiparous sows fed in drylot. In that study, a basal diet composed of ground shelled corn, ground ear corn, ground oats, meat and bone scraps, soybean meal and mineral mixture was compared with a second diet where sun-cured ground alfalfa was added at the level of 18% of the diet. The results showed that the inclusion of alfalfa had no effect on breeding performance but significantly increased the number of live piglets farrowed and number of piglets weaned. When examined early in gestation, sows which had received the alfalfa diet possessed a greater number of corpora lutea than those fed the diet without alfalfa.

De Pape et al. (1953) fed three diets containing alfalfa to sows during gestation and lactation. These diets consisted of 15% sun-cured alfalfa plus 0.5% aureomycin-APF (animal protein factor) supplement, 15% sun-cured alfalfa or 15% dehydrated alfalfa pellets. A highly significant adverse effect was measured when dehydrated alfalfa pellets were substituted for sun-cured alfalfa meal in the gestation-lactation diet as reflected by the number of piglets weaned per sow, 7.3 vs. 5.9, and the total weight of piglets weaned per sow, 93.5 vs. 63.4 kg. Out of the total number of piglets farrowed, the percent mortality at weaning was 16% to 20% higher when sows were fed dehydrated alfalfa pellets. The lower reproductive performance indicated that dehydrated alfalfa in a pelleted form was inferior to sun-cured alfalfa meal as a feed component in diets for gestating-lactating sows.

Silage and haylage fed during gestation has been reported also to produce satisfactory reproductive performance (Terrill et al., 1953; Conrad and Beeson, 1954, 1955; Johnson et al., 1957; Hoagland et al., 1963). Terrill et al. (1953) allotted bred sows to one of the following treatments: 1) a standard gestation diet; 2) grass-legume silage (containing 20% ground corn) fed to replace as much as possible of the diet fed in treatment 1 and 3) self-fed a 25% corn cob diet. Results showed that gestation weight gains and the farrowing performance of all sows in each

dietary treatment was satisfactory and that the grass-legume silage replaced 42% of the diet fed in treatment 1. Conrad and Beeson (1954) compared a basal diet composed mainly of yellow corn, ground oats and alfalfa meal, with that of a grass-legume silage and a corn silage fed to sows during gestation. They reported that both silages produced satisfactory results when adequately supplemented with protein, vitamins and minerals. It was also reported that sows fed corn silage during gestation farrowed 1.4 to 2.0 more piglets per litter than sows on the basal diet (Conrad and Beeson, 1955). Johnson et al. (1957) obtained good reproductive performance when sows were fed corn silage supplemented with a 20% protein corn silage balancer containing carbohydrates, protein, vitamins, minerals and antibiotics. Similar reproductive performance has been obtained when sows were fed alfalfa haylage during gestation (Hoagland et al., 1963).

A study in which self-fed diets were compared with a basal hand-fed diet during gestation was carried out by Conrad and Beeson (1956). The basal diet was composed of 67% ground corn, 15% dehydrated alfalfa meal, 6% soybean meal, 6% meat and bone scraps plus vitamins and minerals. The self-fed diets were composed mainly of 35 to 40% ground corn, 15 to 35% ground corn cobs and 5 to 35% dehydrated alfalfa meal. The chemical analysis of these diets revealed that the major difference was crude fiber content which was

5% for the basal diet and 13% for the self-fed diet. They reported that gestation weight gain, average number of piglets farrowed per litter and the number of piglets weaned per litter were higher in sows consuming self-fed diets.

More recently, as feed grain prices have increased, higher dietary levels of alfalfa, orchardgrass, wheatgrass, or prairie hays have been fed to sows in order to reduce feed costs while maintaining adequate reproductive performance (Danielson and Noonan, 1975; Pollmann et al., 1979, 1980; Calvert et al., 1985; Holzgraefe et al., 1986).

Danielson and Noonan (1975) conducted a series of feeding trials with crossbred primiparous sows to evaluate gestation diets containing 0, 25, 33, 66 and 96.75% alfalfa hay, 66% prairie hay and 25% dehydrated alfalfa meal. In trial 1, they fed gestation diets containing 0, 33 and 66% alfalfa hay at the daily rate of 1.91, 2.27 and 2.73 kg, respectively. These levels of forages allowed a metabolizable energy (ME) intake of 5.3, 5.0 and 4.7 Mcal/sow/day. Trial 2 differed from trial 1 by the addition of a 66% prairie hay fed at the daily rate of 2.73 kg or 4.6 Mcal of ME. Sows in trial 3 were fed diets containing 0, 25 and 96.75% alfalfa hay and 25% dehydrated alfalfa meal at the daily rate of 2.27 kg. These levels provided 6.3, 5.8, 2.6 and 5.9 Mcal of ME/sow/day, respectively. Sows in trial 4 were fed a 96.75% alfalfa hay diet at a daily rate of 1.85 kg which provided 2.0 Mcal of ME/sow/day during each of

three consecutive gestation periods. All diets were fed once daily in pelleted form from breeding through farrowing. Following parturition, sows were fed ad libitum a conventional lactation diet until piglets were weaned. In trial 1, gestation weight gain by sows, number of live piglets farrowed per litter and individual weaning weights at 42 days did not differ among dietary treatments. However, individual birth weights and number of piglets weaned decreased ($P < .01$) as the percentage of alfalfa hay was increased. In trial 2, sows fed the 66% prairie hay diet gained less weight ($P < .05$) during gestation than those fed diets containing 33% and 66% alfalfa. Addition of alfalfa hay or prairie hay had no effect on the number of piglets born alive, but the piglets from the sows fed the 0% alfalfa and 66% prairie hay diets were heavier ($P < .05$) at birth than the piglets from sows fed the 33% alfalfa diet. Sows fed 33% alfalfa hay diet also produced fewer weaned piglets per litter than those fed the 0% and 66% alfalfa hay, and 66% prairie hay diets. Individual piglet weaning weights were not affected by dietary treatment. In trial 3, gestation weight gain was greatly reduced by the 96.75% alfalfa hay diet ($P < .05$) but not by the 25% dehydrated alfalfa meal diet. The sows that received the 25% dehydrated alfalfa meal diet produced fewer ($P < .05$) live piglets per litter at birth than did sows on the other dietary treatments, but individual piglets birth weights

were heavier ($P<.05$) for sows fed the diet containing 25% dehydrated alfalfa meal. There were more ($P<.05$) piglets weaned from sows fed the 25% alfalfa hay diet than from those fed either the 25% dehydrated alfalfa meal diet or the diet containing no alfalfa. The piglets from sows fed the 25% dehydrated alfalfa meal were heavier ($P<.05$) at weaning than those from sows on the other dietary treatments. In Trial 4 of the same experiment, reproductive performance was unaffected when sows were fed the 96.75% alfalfa hay diet through three successive gestations. In all trials, the gestation diet containing the highest level of alfalfa hay, produced the greatest percentage of sows farrowing, and consequently the highest total piglet weights at weaning. Therefore, the authors concluded that alfalfa hay could be justified economically when fed at high levels to gestating swine.

In an experiment conducted by Pollmann et al. (1979), crossbred sows in their second or third parity were used to compare the nutrient value of pelleted gestation diets consisting of 97% sun-cured alfalfa hay, 66% tall wheat grass or a conventional corn-soybean meal diet. All sows were fed an equivalent of 5.0 Mcal of ME/sow/day from breeding until 110 days postcoitum. At that time the lactation diet was started. Gestation weight gain was highest ($P<.01$) for sows on the corn-soybean meal diet and lowest ($P<.01$) for those fed the 66% tall wheat grass.

Although no statistical differences were found in the number of piglets born alive, piglets alive at days 7 and 14 and the piglet weights at birth and at weaning, individual weights and survival rates of piglets from sows fed the corn-soybean meal diet were slightly higher when compared to the groups fed forages. Throughout the lactation period, sows fed the corn-soybean meal diet during gestation lost more weight ($P < .01$) than those fed alfalfa or wheat grass diets. Sows on the high fiber diets tended to consume more feed during lactation. In a second study, Pollmann et al. (1980) used crossbred sows to evaluate the effects of feeding a 50% sun-cured alfalfa diet or a conventional corn-soybean meal diet during gestation on reproductive performance for three successive parities. The same diets contained 0% or 8% tallow during lactation. Gestation diets were pelleted and fed at the rate of 6.0 Mcal of ME/sow/day for the first 90 days postcoitum. Thereafter, lactation diets were initiated. Results showed that, compared to sows fed the conventional diet, a higher percentage of the sows fed the alfalfa diet completed the three reproductive cycles. They also had lower ($P < .05$) gestation weight gains up to 90 days postbreeding and a higher ($P < .05$) number of piglets per litter at 14 days postpartum. Live piglets farrowed per litter and average piglet weight at 14 days did not differ between the sows fed diets containing alfalfa or corn-soybean meal but the average birth weight of piglets

was lower ($P<.05$) for sows fed alfalfa. The survival rate pooled over the three reproductive cycles was 8% higher for the piglets from sows fed alfalfa.

More recently, Calvert et al. (1985) conducted two experiments with second parity crossbred sows fed diets containing 5 or 50% alfalfa meal (exp. 1) or 5, 50 or 95% alfalfa meal (exp. 2) beginning 30 days after breeding and continuing throughout a 21-day lactation period. Experimental diets were fed in pelleted form at the rate of 2.0 kg/sow/day. This rate provided 6.4, 5.4 and 4.3 Mcal of ME/sow/day for the 5, 50 and 95% alfalfa levels, respectively, during gestation. Sows were fed ad libitum during lactation. Gestation weight gains were reduced ($P<.05$) as the level of alfalfa increased in the diet. Sows on the 95% alfalfa meal diet lost an average of 2.0 kg during gestation. Piglets farrowed alive and average weight at birth or weaning were not affected by dietary treatment. The diet containing 95% alfalfa fed to sows during gestation and lactation lowered ($P<.01$) piglet weaning weight. Sows fed diets containing 50 and 95% alfalfa meal lost an average of 21.0 and 37.0 kg, respectively, from breeding through 21 days of lactation as compared with a 5.0 kg loss in sows fed the 5% alfalfa diet. The authors concluded that swine lactation diets should not contain greater than 50% alfalfa.

In 1986, Holzgraefe et al. conducted a study in which crossbred sows were fed diets containing 46% alfalfa-orchardgrass hay or corn-soybean meal through two successive gestations. Dietary treatments were initiated at 35 days postcoitum and continued until parturition. Metabolizable energy intake was equalized to 6.6 Mcal/sow/day during gestation and a standard 14% crude protein lactation diet was fed ad libitum throughout lactation. Gestation weight gains were similar for both dietary groups. There was no significant difference between dietary treatments in number of piglets born alive, piglet birth weight, piglet weight at 14 days postpartum or sow rebreeding efficiency. The alfalfa-orchardgrass treatment effected greater ($P<.04$) weight loss from 109 days postcoitum to 14 days postpartum and increased ($P<.002$) feed consumption during lactation. The authors concluded that the 46% alfalfa-orchardgrass hay diet was essentially equal to the corn-soybean meal diet with regard to sow reproductive performance.

A review of the research articles given herein demonstrate clearly that the reproductive performance of sows was not adversely affected when high fiber diets were included during gestation.

Effect of Fiber vs Grain, Carbohydrate and/or Fat on Milk Composition

Survival of the piglet from birth to weaning is an important factor for assessing efficient productivity. It is during the preweaning period that 25% of all live-born piglets fail to survive, resulting in a large economic loss to the swine industry (Stanton and Carroll, 1974).

Since the preweaned piglet is dependent on milk from the sow for food, a better understanding of milk yield and composition of milk from sows fed unconventional diets during gestation should be more thoroughly researched.

The secretion of the mammary gland for the first 24 hours of lactation is colostrum. The nutrient composition of colostrum is considerably different from that of milk secreted later in the lactation period. Colostrum is higher in percentage of total solids and protein than milk, but lower in ash, fat and lactose (Pond and Maner, 1984). On the average, the gross composition of colostrum and milk from sows is 25.6 and 18.3%, 5.0 and 6.7%, 15.7 and 5.4%, 3.1 and 5.6%, and 0.80% and 0.96% in total solids, fat, protein, lactose and ash, respectively (Okai et al., 1977; Klobasa et al., 1987). Gross energy content of fresh colostrum and milk has been reported to be 1.6 and 1.10 kcal/g, respectively (White and Campbell, 1984; Okai et al., 1977).

The diet fed during gestation and/or lactation has an effect on the composition of colostrum and/or milk. It has been shown that the addition of up to 10% tallow or corn oil and raw soybeans to diets fed during late gestation and lactation increases the percentages of fat and total solids in colostrum and milk (Friend, 1974; Boyd et al., 1978; Okai et al., 1977; Stahly et al., 1981; Pettigrew, 1981; Boyd et al., 1982; Lellis and Speer, 1983; Crenshaw and Danielson, 1985; Shurson et al., 1986; Coffey et al., 1987; Schoenherr et al., 1989b) and that dietary carbohydrate source during lactation, i.e., fructose and dextrose, affects lactose and protein concentration in milk (White and Campbell, 1984; White et al., 1984). In a series of cooperative studies conducted by the NCR-42 Committee on swine nutrition (1978) in which sows were fed different protein levels during gestation (9% and 15%) and lactation (12%, 16% and 20%), it was reported that protein concentration in milk increased as the protein level of the gestation and lactation diets increased, whereas fat concentration increased only when dietary gestation protein level increased.

Also, when sows were fed a low energy level (10.4 vs. 14.2 Mcal of ME/sow/day) during lactation, fat, protein, total solids and energy concentrations of milk increased when compared to sows fed a high energy level (Noblet and Etienne, 1986). The feeding of high fiber diets to growing-finishing pigs and pregnant sows increases the

acetate:propionate ratio of cecal and colon contents (Rerat, 1978; Gargallo and Zimmerman, 1980; Kass et al., 1980b; Gargallo and Zimmerman, 1981b; Ehle et al., 1982; Varel et al., 1984; Holzgraefe et al., 1985a) and these volatile fatty acids, among others, are absorbed from the large intestine (Kass et al., 1980b; Yen and Killefer, 1987; Rerat et al., 1987; Giusi-Perier et al., 1989) and utilized for systemic metabolism. In lactating cows, high ruminal acetate:propionate ratios are positively correlated with milk fat percentage (Maynard et al., 1979; Tyrrell, 1980) and in lactating sows it has been shown that acetate is incorporated into milk fat (Linzell et al., 1969; Spincer et al., 1969). Holzgraefe et al. (1986) hypothesized that the feeding of an alfalfa-orchardgrass diet to sows during gestation would increase milk fat percentage. However, no increase in milk fat percentage was obtained when a 46% alfalfa-orchardgrass hay diet was fed during gestation (Holzgraefe et al., 1986) or a 48% wheat bran diet during lactation (Schoenherr et al., 1989b).

Digestibility of Fiber

Dietary fiber has been described as the sum of lignin and the polysaccharides that are not digested by the endogenous secretion of the digestive tract. These compounds include cellulose and a variety of so-called noncellulosic polysaccharides, the most predominant being the hemicelluloses (Partridge, 1982).

Van Soest (1964, 1967) improved the crude fiber analysis by using detergents to solubilize portions of plant material. The neutral detergent fiber (NDF) procedure separates the cell wall material from the cell contents. Cell wall contents include cellulose, hemicellulose, lignin, and silica. These components, alone or in combination differ in nutritional availability depending on the kind and maturity of the plant, and age and species of the animal fed (Chandler, 1978). Cell content consists of sugars, starches, soluble carbohydrates, soluble proteins, pectin, nonproteic nitrogen, and other water soluble materials like minerals and several vitamins.

The acid detergent fiber (ADF) procedure renders a low nitrogen residue that recovers lignin and cellulose by extracting plant tissue with strongly acid solutions of quaternary detergent. The ADF residue does not represent an ideal estimate of dietary fiber, but it is a fraction of the cell wall that is useful in partitioning the major cell wall components (Van Soest, 1983).

The ability of the pig to digest fiber was first established by Scheunert (1906) and has been confirmed by numerous investigators and reviewed by Rerat (1978), March (1979), Pond (1987) and Varel (1987). In pigs, fibrous material, primarily cellulose and hemicellulose, is digested mainly in the large intestine by anaerobic microbial fermentation. The volatile fatty acids (VFA) produced by

this fermentation, i.e., acetic, propionic and butyric, are absorbed from the cecum and colon to provide part of the energy requirements for the animal (Kass et al., 1980 b; Rerat et al., 1987; Giusi-Perier et al., 1989).

Pond (1987) stated that the acceptability of fibrous feeds as energy sources for swine depends on such factors as the cell wall content of the plant, the degree of microbial fermentation in the large intestine and the extent of absorption and utilization of the VFA produced. The quantity of cell wall structural constituents of the plant (cellulose, hemicellulose and lignin) is important because it is the fraction which, if it is to be metabolized by the animal, must first be degraded by gastrointestinal microorganisms (Van Soest, 1984). Therefore, fiber sources with less cell wall content will be more efficiently digested. Grasses as a whole contain more plant cell wall and less lignin than legumes, with perennials containing more cell wall constituents than some annuals (Van Soest, 1975).

The number and activity of cellulolytic bacteria in the large intestine increase when pigs are fed high fiber diets (Varel, 1987; Varel et al., 1988). Varel et al. (1984) found that fecal samples of growing-finishing pigs fed 35% alfalfa meal in their diets had a greater number and activity of cellulolytic bacteria than those fed 0% alfalfa meal. They concluded that prolonged feeding of a diet high

in fiber can enhance microbial fermentation. Similar trends in bacterial number and activity have been obtained with sows fed diets containing graded levels of alfalfa meal (0%, 40%, 50%, or 96%) during gestation (Varel and Pond, 1985; Pollmann et al., 1983).

Although VFA are rapidly absorbed by swine, the precise amount of energy that the host animal receives from the VFA produced by microbial fermentation in the large intestine has not been determined (Pond, 1987). Friend et al. (1964) calculated a possible energy contribution by VFA in the pig to be between 15 and 28% of the maintenance energy requirement. Imoto and Namioka (1978) have reported that VFA absorbed from the large intestine of growing pigs provide, as an average, 10.5% of the metabolizable energy for maintenance.

Kass et al. (1980b) conducted an experiment to determine the amount of VFA produced in the large intestine when swine were fed 0, 20, 40 or 60% alfalfa meal. This study showed that VFA produced in the large intestine can provide up to 14% of the energy required for maintenance in the growing-finishing pig. Gargallo and Zimmerman (1981b) have reported that VFA produced in the cecum and colon during a 24 hour period could represent, as an average, 6.2%, 5.6% and 5.0% of the energy required for maintenance in 95-kg pigs fed 2%, 10% and 20% added sunflower hulls, respectively.

Rerat et al. (1987) fitted permanent catheters in the portal vein and carotid artery as well as an electromagnetic flow probe around the portal vein of finishing swine fed a diet containing 6.5% alfalfa meal in order to measure VFA absorption from the large intestine. In this study, the absorption of VFA represented about 30% of the energy requirements for maintenance. In other studies, fiber digestibility varied widely with the source and level of fiber in the diet (Forbes and Hamilton, 1952; Kass et al., 1980a), the level of feeding to the experimental animal (Cunningham et al., 1962), and physical characteristics such as feed particle size (Nuzback et al., 1984).

Forbes and Hamilton (1952) conducted an experiment to determine the effect of source of crude fiber on its digestibility and degree of utilization by growing-finishing pigs. Woodflock, Ruffex, wheat straw pulp, alfalfa meal, or oat hulls, were added to a basal diet in amounts to give equivalent cellulose values. Cellulose digestibility was found to be higher for pigs fed alfalfa meal and least for those fed oat hulls. It was concluded that the decrease in cellulose digestibility was associated with a high degree of cellulose lignification. Keys et al. (1969) reported that swine fed diets containing 50% of alfalfa, brome or orchardgrass hays digested NDF and hemicellulose from grass to a greater extent than from alfalfa. However, dry matter in the diet containing alfalfa was more digestible than that

of the grasses. In a study with gravid sows, Pollmann et al. (1979) fed diets containing either 97% alfalfa meal, 66% tall wheat grass or a conventional corn-soybean meal diet, during gestation. It was found that NDF and hemicellulose digestibility did not differ between diets containing alfalfa and tall wheat grass; however, the digestibilities of dry matter, ADF and cellulose were reduced by the diet containing tall wheat grass. As fiber content of the diets increased, digestibility of dry matter and fiber components decreased, but as the digestive system of swine became more acclimated to the fibrous diets more components of fiber were utilized with time.

Ehle et al. (1982) reported that digestibilities of dry matter, NDF, cellulose and hemicellulose differed among dietary fiber sources when mature pigs were fed diets containing similar NDF content where fiber sources were provided by 15% cellulose (Solka Floc), 31% dehydrated alfalfa meal, 31% coarse wheat bran, or 47% fine wheat bran. Pond et al. (1986a) conducted a study in which pigs with a mean body weight of approximately 80 kg were fed a corn-soybean meal control diet or fiber diets containing 20% alfalfa meal or 10% ground corn cobs. They reported that NDF, ADF and cellulose digestibilities were decreased when the diet containing 10% corn cobs was compared to the 20% alfalfa meal diet. Lignin digestibility was not affected by dietary fiber source. Inclusions of the fibrous feeds

increased digestibilities of NDF, ADF and cellulose and reduced digestibilities of dry matter and lignin when compared to the control diet.

Moore et al. (1988) fed a corn-soybean meal diet or fiber diets containing either 15% oat hulls, 15% soybean hulls or 20% alfalfa meal to growing pigs. Digestibilities of NDF, ADF, cellulose and hemicellulose were reduced by oat hulls and alfalfa meal, but not by soybean hulls. When graded levels of cellulose, up to 40% of the diet, were fed to growing or finishing pigs, there was a reduction in the digestibilities of dry matter and cellulose as the level of cellulose increased in the diet (Cunningham et al., 1962; Farrell and Johnson, 1970; Gargallo and Zimmerman, 1980, 1981a). In a similar manner, the inclusion of graded levels of alfalfa meal, up to 80% in growing-finishing pig diets (Kass et al., 1980a; Varel et al., 1988) and up to 95% in gestation diets (Pollmann et al., 1983; Calvert et al., 1985), reduced the respective digestibilities of dry matter, NDF, ADF, cellulose and hemicellulose. Keys et al. (1970) reported that feeding orchardgrass to pigs averaging 84 kg in body weight at levels of 20%, 40% and 60% of their diets had no effect on ADF and cellulose digestibilities. However, dry matter and hemicellulose digestibilities decreased as the level of orchardgrass increased in the diet. The feeding of a 46% alfalfa-orchardgrass hay diet during gestation has also been reported to reduce the

digestibilities of dry matter, NDF, ADF, and hemicellulose when compared to the corn-soybean meal diet (Holzgraefe et al., 1985b). Similar reductions in dry matter and digestibilities of fiber constituents, i.e., NDF, ADF, cellulose or hemicellulose, have been measured when feeding different levels of alphacel (Sherry et al., 1981), oat hulls (Moser et al., 1982), ground corn cobs (Frank et al., 1983), ground oats (Ranvindran et al., 1984), and peanut hulls (Lindemann et al., 1986) to growing or finishing pigs. It has been reported that the addition of graded levels of soybean hulls, up to 30%, in diets of growing-finishing pigs and gestating sows (Kornegay, 1978; 1981) has increased the digestibilities of NDF, ADF, hemicellulose, cellulose and lignin.

Cunningham et al. (1962) reported that the reduction of feed intake to a maintenance level in finishing pigs caused an increase in crude fiber digestibility when the fiber source was 0% and 40% Solka-Floc. Nuzback et al. (1984) also reported an increase in the digestibilities of dry matter, NDF, ADF and cellulose when the particle size of a 50% alfalfa hay gestation diet was reduced from 12.5 mm to 6.25 mm.

Utilization of Dietary Fiber

Utilization of nutrients from dietary fiber by growing-finishing swine is minimal. High levels of dietary fiber have been shown to reduce average daily gain and feed

utilization (Bohman et al., 1953, 1955; Hanson et al., 1956; Becker et al., 1956; Heitman and Meyer, 1959; Kornegay, 1978; Kass et al., 1980a; Powley et al., 1981; Frank et al., 1983; Lindemann et al., 1986; Pond et al., 1989), and the depression in growth has been attributed to a reduction in the digestible energy concentration as the level of fiber is increased in the diet. Therefore, the ability of the pig to maintain adequate intake of digestible energy appears to be one of the factors influencing weight gains by growing-finishing pigs consuming high fiber diets. However, feeding high fiber, low energy diets to sows during gestation has been successful, and supports satisfactory reproductive performance of the sow (Danielson and Noonan, 1975; Pollmann et al., 1980; Calvert et al., 1985; Pond et al., 1985; Holzgraefe et al., 1986).

It has been reported that energy and nitrogen metabolism, i.e., digestibility and/or retention, are reduced when growing-finishing pigs (Cunningham et al., 1962; Farrell and Johnson, 1970; Keys et al., 1970; Farrell, 1973; Kornegay, 1978; Kass et al., 1980a; Gargallo and Zimmerman, 1981; Sherry et al., 1981; Ehle et al., 1982; Frank et al., 1983; Ranvindran et al., 1986; Pond et al., 1986a; Lindemann et al., 1986; Moore et al., 1988; Varel et al., 1988) and sows during gestation (Pollmann et al., 1979; Young and King, 1981; Kornegay, 1981; Pollmann et al., 1983; Nuzback et al., 1984; Holzgraefe et al., 1985b; Calvert et

al., 1985; Pond et al., 1986b) and lactation (Schoenherr et al., 1989a) were fed high fiber diets. The apparent digestibility of ether extract was also lower when swine were fed high fiber diets (Kornegay, 1978; Pond et al., 1986b).

One of the mechanisms by which high levels of fiber affects the apparent digestibility of dietary nutrients, is through accelerating the rate of digesta passage (Farrell and Johnson, 1970; Kass et al., 1980a; Ranvindran et al., 1984; Lindemann et al., 1986; Holzgraefe et al., 1985a,b). With a faster rate of passage, less opportunity exists for both enzymatic and microbial digestion in the digestive tract. Metabolic fecal nitrogen is also increased when fibrous materials are fed to swine, and this component contributes to a further reduction in nitrogen digestibility (Forbes and Hamilton, 1952; Cunningham et al., 1962; Farrell, 1973; Gargallo and Zimmerman, 1981a; Ranvindran et al., 1984; Pollmann et al., 1979; Holzgraefe et al., 1985b). Metabolic fecal nitrogen is contributed by nitrogen from epithelial cells that have been abraded or sloughed-off from the intestine as a result of the mechanical action of fiber, and from nitrogen derived from bacterial cells produced in the large intestine (Farrell, 1973; Ehle et al., 1982). Schneider and Platt (1975) stated that it is not unusual for the ether extract of the feces to exceed that of the feed, since fecal lipids consists of undigested dietary

lipids, indigestible compounds such as pigments and waxes, metabolic fecal lipids such as residues of the digestive juices and microbial fatty acids.

Effect of Dietary Fiber on Blood Constituents

Few studies have been published on concentrations of blood constituents during gestation in sows. The majority of published data report concentrations of blood constituents of the growing-finishing pig or in other animal species. Although much interest exists in the feeding of fiber diets to monogastric species, there is a paucity of data on blood constituents, and data available are often contradictory.

The normal range of concentrations of protein (g/100 ml) and glucose, urea nitrogen, lactic acid, cholesterol, high density lipoprotein cholesterol (HDL-cholesterol), low density lipoprotein cholesterol (LDL-cholesterol) and triglycerides (mg/100 ml) in the blood of swine has been reported to be 5.0-7.7, 65.0-140.0, 7.7-19.0, 5.0-20.0, 47.0-200.0, 32.0-59.0, 64.0-70.0 and 52.0-55.0, respectively (Atinmo et al., 1976; Swenson, 1978; Collings et al., 1979; Gargallo and Zimmerman, 1980, 1981 a,b; Pond et al., 1981; Randall, 1982; Frank et al., 1983; Friendship et al., 1984; Pond and Maner, 1984; Grummer and Carroll, 1988).

It has been reported that blood protein concentration was reduced (Atinmo et al., 1976) or remained unchanged (Wahlstrom and Libal, 1977) when dietary crude protein was

reduced in diets fed during gestation. Blood glucose concentration was found to decrease when different levels of wheat middlings (Collings et al., 1979), alfalfa (Pond et al., 1981) or corn cobs (Frank et al., 1983) were fed to growing-finishing pigs. However, the concentration of blood glucose was increased when levels up to 20% of sunflower hulls were fed to finishing pigs (Gargallo and Zimmerman, 1981b). Feeding diets containing either 10% or 14% in crude protein during gestation did not affect the concentration of blood urea nitrogen (Wahlstrom and Libal, 1977); however, feeding fibrous diets to growing-finishing pigs was found to increase (Frank et al., 1983), decrease (Gargallo and Zimmerman, 1981b) or have no effect on (Gargallo and Zimmerman, 1980, 1981a) the concentration of blood urea nitrogen. Collings et al. (1979) reported that feeding graded levels of wheat middlings up to 30% of the diets of growing-finishing pigs did not affect blood cholesterol concentration, however, blood cholesterol was reduced when diets containing alfalfa (Pond et al., 1981) or cellulose (Gargallo and Zimmerman, 1981a) were fed to growing-finishing pigs.

There is also a paucity of information with respect to effects of high fiber diets on concentrations of blood lactic acid, HDL-cholesterol and LDL-cholesterol in gestating swine. This fact invited investigative study regarding concentrations of these blood constituents.

Perennial Peanut

Florigraze perennial peanut (Arachis glabrata Benth.) is a warm-season, perennial forage legume having value as both a hay and grazing crop and is adapted to well drained soils in climates with wet summers and dry, cold winters with sporadic frosts (Otero, 1952; Prine et al., 1981). This cultivar should also be adapted to humid tropics and subtropics around the world (Franca-Dantas, 1982). Florigraze variety of perennial peanuts are also drought tolerant, growing further into the dry season than tropical grasses, thus providing a source of protein and energy for livestock (Franca-Dantas, 1982).

Botany

Perennial peanut has been described by Bogdan (1977) as

a perennial legume with underground creeping, much-branched rhizomes (root stocks) producing short suberect, above-ground shoots. Leaves (6-20 mm long and 5-14 mm wide) with four leaflets which are broadly elliptic and subglabrous or glabrous underneath. Axillary flowers are produced in the lower part of the stem. The receptacle is a filiform tube 2.5-10 cm long; the calyx is 6-7 mm long and is standard yellow to orange; orbicular and 10-12 mm in diameter. Pods are small, 10 mm long and 5-6 mm thick, acute, longitudinally striate. Seeds are ovoid, pale (Bogdan, 1977, p. 321).

The botanical description of perennial peanut as summarized by Franca-Dantas (1982) is as follows:

Cultivar: Florigraze

Crop: Rhizoma peanut

Species: glabrata

Section: Rhizomatosae

Genus: Arachis

Family: Habaceae

Order: Leguminosae

Origin and Distribution

Arachis is the genus of a South American plant consisting of 40-70 species, many, as of yet, undescribed (Gregory and Gregory, 1976). This genus evolved on the essential limitations of the ancient Brazilian shield and its drainage basins. It is still naturally confined in the countries of Brazil, Bolivia, Paraguay, Uruguay, and Argentina (Prine, 1964; Gregory and Gregory, 1979). Species in areas of high rainfall are perennial and those in semi-arid areas are annual (Gregory and Gregory, 1976).

Eight species of wild peanuts are recognized in the genus Arachis, and they are: tuberosa, A. guaranítica, A. angustifolia, A. helodes, A. glabrata, A. marginata, A. villosa, and A. pusilla. All listed are perennials except A. pusilla which is an annual (Herman, 1954).

The three perennial Arachis species having widest distribution in South America are glabrata, marginata, and villosa; the Southern limit of these species is about 35° south latitude. In the Northern Hemisphere, these species may be grown to a latitude that corresponds to the northern boundary of the State of Georgia in the United States (Prine, 1964).

Selection

USDA records show that A. glabrata was found growing on rich black earth in the streets of Campo Grande, Mato Grosso, Brazil, and that it was introduced to the United States by W. Archer in 1936 (Prine, 1964; Prine et al., 1981). After 1936, several perennial peanut introductions were evaluated by the Soil Conservation Service (SCS), Plant Materials Center at Brooksville, Florida. Presently, small acreages of the SCS selections, which include Arb (PI 118456) and Arblick (PI 262839), are growing in the United States (Prine et al, 1981).

Gainesville Selection 1, later named Florigraze rhizoma peanut, was selected by G. Prine in 1962. Florigraze is believed to be a seedling or mutant from Arb (Prine, 1972). Florigraze was released in 1978 by Florida Agricultural Experiment Stations and Soil Conservation with the following description:

Florigraze peanut is finer stemmed and has narrower leaflets on the quadrifoliate leaves than Arb or Arblick. The rhizome diameter of Florigraze is small and usually has a larger number of rhizomes per unit area of soil. A rhizomateous mat of Florigraze has more budding points and develops more shoots per unit of soil surface than similar sized mat of Arb and Arblick. Florigraze and Arb flowers are yellow-orange, whereas Arblick flowers are creamy-yellow. Florigraze usually does not flower as profusely as Arb or Arblick. Seeds develop rarely on these three rhizome peanuts (Prine et al., 1981, p. 2).

Forage Potential

Perennial peanut appears to have promise as a forage legume on well-drained soils. Some of the uses for perennial peanut as suggested by Prine et al. (1981) are:

1. Hay production: Perennial peanut can be used in a pure stand or in mixture with grasses for hay. A satisfactory quality hay is produced when the forage is cut twice a year. The legume portion should make up to 75% or more of a mixture grown for hay.
2. Dehydrated products: The persistence, high quality, and yield of perennial peanut make it a potential crop for dehydrating as a high quality hay or leaf meal.
3. Grazing: Close defoliation or heavy grazing will not eliminate established perennial peanut from a stand, but under such conditions, perennial peanut produces a rosette type growth, and leaves are oriented flat on the ground where they cannot easily be removed by grazing. When it is not overgrazed, it assumes an erect habit of growth and is easily consumed by grazing animals (Prine et al., 1981, p. 15).

Perennial peanut is an excellent hay-making legume because of its high dry matter yield, quick drying and early baling with low leaf loss (Prine et al, 1981). Dry matter yields for Florigraze perennial peanut reported in kg/ha/year are as follows; 4,460 (Blickensderfer et al, 1964), 6,270 (Prine, 1972, Prine et al., 1981), 10,377 (Prine, 1980) and 10,460 kg/ha/year (Romero et al., 1987).

Perennial peanut has also been planted in mixture with Pensacola bahiagrass (Paspalum notatum), pangolagrass (Digitaria decumbens) and bermudagrass (Cynodon dactylon). In these studies, each perennial peanut mixture was more productive than the grass it was mixed with (Prine, 1964; Prine et al., 1981; Breman, 1980).

Chemical Composition

Perennial peanut; on a dry matter basis; contains 10-18% crude protein, 2-4% ether extract, 20-28% crude fiber, 44-48% nitrogen free extract, and 9-11% ash content (Prine, 1964; Otero, 1952; Prine et al., 1981, 1986; Romero et al., 1987). Romero et al. (1987) reported that perennial peanut contains 50-56% NDF (cell walls) and 38-46% ADF.

CHAPTER 3
REPRODUCTIVE PERFORMANCE OF SOWS FED
PERENNIAL PEANUT HAY DURING GESTATION

Introduction

Prior to 1960, pasture was considered essential in meeting the nutritional requirements of swine for reproduction. Sows that were denied pasturage often farrowed fewer piglets per litter and farrowings were more likely to produce weak or dead piglets. Research which followed that era greatly expanded knowledge of nutrient requirements for the gestating sow, and, as a result, diets currently fed are formulated to contain the essential nutrients to support reproduction. Currently these nutrients are derived from complete feeds which are mixtures of cereal grains and soybean meal together with supplemental vitamins and minerals. In Florida, however, cereal grains are not produced in adequate quantities to support the swine industry and research to identify alternative feedstuffs is needed.

Among the alternatives to corn:soybean meal diets fed to gestating sows is the use of high fiber diets from pasture forages to meet part of the nutrient requirements for reproduction. In recent years, it has been reported that feeding high fiber diets to sows during gestation does

not affect reproductive performance (Danielson and Noonan, 1975; Pollmann et al., 1979, 1980; Calvert et al., 1985; Holzgraefe et al., 1986). Feeding alfalfa to gravid sows has been reported to increase the number of piglets farrowed, and improved piglet survival and weight at weaning (Teague, 1955; Seerley and Wahlstrom, 1965). However, this observation should be interpreted cautiously since it may or may not apply to other studies.

An ambitious program to introduce a nitrogen-fixing legume other than alfalfa as a pasture-type forage in Florida is presently underway in several northern counties of the state. The legume being introduced is perennial peanut which establishes from rhizomes, does not require nitrogen fertilizer and appears to be drought, disease and insect resistant (Prine et al., 1981). The objectives of these experiments were: 1) to determine the maximum level at which perennial peanut hay could be added to sow gestation diets and yet permit acceptable reproductive performance; 2) to determine if this maximum level of perennial peanut hay could be fed during three successive gestations; and 3) to compare the composition of colostrum at day 1 and milk at day 7 of lactation when sows were fed a standard gestation diet or a diet containing perennial peanut hay during gestation.

Materials and Methods

Three experiments were conducted at the Swine Research Unit, Agricultural Research and Education Center, Route 2, Box 2181, Live Oak, FL 32060. In experiment 1, 23 primiparous crossbred sows were divided into three groups of six sows each; and one group of five sows. Each group of sows was randomly assigned at breeding to one of four gestation diets containing 0%, 40%, 60% and 80% ground perennial peanut hay (PPH). In experiment 2, sows that were allotted to the 0% and 80% PPH gestation diets during experiment 1, continued in their respective diets over a period of three additional successive parities. In experiment 3, 20 second-parity crossbred sows were randomly assigned in equal sized groups at breeding to the 0% and 80% PPH gestation diets.

The fresh perennial peanut forage was cut and allowed to dry under field conditions for a period of three days. Subsequently, it was compressed into square bales, then it was passed through a portable hammer mill¹ with a screen having openings of 9 mm. Ground PPH samples were analyzed for nitrogen content by the standard Kjeldahl procedure (AOAC, 1980) and values obtained were used to formulate the

¹Gehl Bros. Mfg. Co., West Bend, WI.

experimental gestation diets (table 1). Sows in each of the three experiments were fed diets calculated to offer 127.0 kcal/kg BW^{.75}/day in metabolizable energy (ME), and were adjusted biweekly to accommodate for weight gain during gestation. Sows were fed individually their measured ration of the diet once at 0900 hr each day during experiment 1 and twice at 0900 hr and 1800 hr during experiments 2 and 3. Throughout the gestation period, sows were penned, by experimental diet, in an open-sided shelter on solid concrete floors. Each pen contained six sows in gestation crates to allow individual feeding. Water was supplied on an ad libitum basis during gestation and lactation.

At approximately 110 days postcoitum, sows were moved into a central farrowing barn and confined in individual farrowing crates with plastic-coated expanded metal floors. Following parturition, gestation diets were discontinued and all sows were fed ad libitum a standard corn-soybean meal lactation diet containing 15% crude protein. Feed intake was measured during lactation only during experiment 3.

Sows were weighed at breeding, 110 days postcoitum, within 24 hr following parturition and at 21 days postpartum. Placental membranes were collected and weighed immediately after farrowing. Number of piglets and piglet weights were recorded at birth and at days 7, 14 and 21 postpartum. No creep feed was given during lactation, but the piglets had access to the sow's feed.

Table 1. Composition of Gestation Diets

Ingredient	Diets ^a			
	0% PPH	40% PPH	60% PPH	80% PPH
Peanut hay ^b		39.7	59.7	79.6
Corn	81.3	49.0	32.5	16.0
Soybean meal	15.5	8.5	5.0	1.5
Def. Phos.	1.8	1.9	2.0	2.1
Limestone	.6			
Salt	.5	.5	.5	.5
Vitamin Premix ^c	.3	.3	.3	.3
Mineral Premix ^d	.1	.1	.1	.1

Calculated analysis, %				
Protein	14.00	14.00	14.00	14.00
Ca	.85	1.26	1.57	1.88
P	.65	.65	.65	.65
ME (Mcal/kg)	3.25	2.39	1.96	1.53

^aPPH = perennial peanut hay.

^bSun-cured perennial peanut hay, ground, (9 mm screen).

^cProvided 7,700 IU vitamin A; 1,100 IU vitamin D₃; 16.5 IU vitamin E; 26.5 mcg vitamin B₁₂; 5.5 mg riboflavin; 33 mg niacin; 22 mg pantothenic acid; 275 mg choline; 4.0 mg menadione; .66 mg folic acid; 2.2 pyridoxine; 1.1 mg thiamine; and 110 mcg biotin per kg of finished feed. Courtesy of Hoffman-LaRoche Inc., Nutley, NJ 07110.

^dSupplied 150 mg zinc; 60 mg manganese; 175 mg iron; 17.5 mg copper; 2 mg iodine; and 40 mg calcium per kg of finished feed. Courtesy of J.M. Huber Corporation, Quincy, IL.

Milk samples were collected from five sows in each dietary treatment (0% and 80% PPH) within 3 hours after parturition and on all sows at day 7 of lactation during experiment 3. A dose consisting of 40 USP units of oxytocin was injected intramuscularly to enhance milk letdown and milk samples were collected by manual expression from functional mammary glands. Immediately after collection, the milk samples were strained through layered cheesecloth and frozen for later analysis. Lactose in milk was determined by the Method of Marier and Boulet (1959), fat by the modified Babcock method (Atherton and Newlander, 1977). Total solids were determined gravimetrically from lyophilized aliquots of whole milk. Ash in milk was determined gravimetrically from the residual following ignition of 1 gram samples of dry milk in a furnace at 550°C. Gross energy was measured with a Parr adiabatic calorimeter² using one gram samples of dry milk. Proteins in milk were calculated as total solids minus lactose, fat and ash. Data for experiments 1, 2 and 3 were analyzed by the General Linear Model procedure (Barr et al., 1979) as a complete random design where sows and/or litters were considered the experimental units. Effects of dietary treatment, parity and dietary treatment x parity were tested for all measurements in experiment 2, and individual

²Parr Instruments, Inc., Moline, IL.

treatment means were separated by using the least significant difference procedure.

Results and Discussion

Experiment 1

The effect of feeding 0%, 40%, 60% and 80% PPH diets during gestation on reproductive lactation and weaning performance is summarized in tables 2 and 3. The feeding of PPH had no significant effect on litter size, piglets born alive and piglets alive at 7, 14 and 21 days postpartum (table 2). Although, litter size and piglets born alive were slightly greater for sows fed the 40%, 60% and 80% PPH diets, the number of weaned piglets was not influenced by dietary treatments fed during gestation. Similar results in birth-to-weaning performance of piglets have been reported when sows were fed alfalfa (Seerley and Wahlstrom, 1965; Danielson and Noonan, 1975; Pollmann et al., 1979, 1980; Calvert et al., 1985; Pond et al., 1986b), alfalfa-orchard grass (Holzgraefe et al., 1986), peanut hulls (Leibbrandt, 1977), oat hulls (Zoiopoulos et al., 1983) or wheat shorts (Young and King, 1981) during gestation. Overlayed piglets and weaning percentage were also not affected by treatments, but there was a tendency for more overlayed piglets from sows fed the 40% and 80% PPH diets which, in part, can explain the lower weaning rate of these two groups (table 2). Table 3 gives birth weights and growth performance of piglets at days 7, 14 and 21 together with net weight gains

Table 2. Effect of Perennial Peanut Hay Fed to Sows During Gestation on Reproductive, Lactation and Weaning Performance (Exp. 1)

Item	0% PPH	40% PPH	60% PPH	80% PPH	SE ^a
Litters	6	6	5	6	
Litter size	8.8	11.0	10.6	11.5	1.26
Piglets					
Born alive	8.5	10.3	10.4	11.2	1.22
Alive, day 7	6.8	6.8	7.2	6.8	1.34
Alive, day 14	6.8	6.7	5.8	6.7	1.37
Alive, day 21	6.7	6.5	5.6	6.7	1.35
Overlaid	.7	1.3	.2	3.0	1.09
Weaned, %	72.7	63.0	57.5	61.4	12.16

Note: Least-square means.

^aPooled standard error of the LS Mean.

Table 3. Effect of Perennial Peanut Hay Fed to Sows During Gestation on the Subsequent Weights of Their Piglets (Exp. 1)

Item	0% PPH	40% PPH	60% PPH	80% PPH	SE ^a
Litters	6	6	5	6	
Piglet wt., kg					
Birth wt.	1.37 ^b	1.34 ^b	1.32 ^b	.97 ^c	.07
7 day wt.	2.53 ^b	2.73 ^b	2.78 ^b	2.05 ^c	.11
14 day wt.	3.71 ^c	4.11 ^{b,c}	4.22 ^b	3.10 ^d	.17
21 day wt.	5.14 ^{c,d}	5.78 ^{b,c}	6.34 ^b	4.84 ^d	.30
Net wt. gain	3.80 ^c	4.44 ^{b,c}	5.01 ^b	3.84 ^c	.29

Note: Least-square means.

^aPooled standard error of the LS Mean.

^{b,c,d}LS Means in rows with different superscripts differ (P<.05).

from birth to 21 days postpartum. The birth and 7-day weights of piglets from sows fed the 0%, 40% and 60% PPH diets were heavier ($P < .05$) than piglets from sows fed the 80% PPH diet. Other researchers (Danielson and Noonan, 1975; Pollmann et al., 1980; Calvert et al., 1985; Pond et al., 1986b) have observed a similar decrease in birth weight when graded levels of alfalfa have been fed during gestation. The 14-day weights of piglets from sows fed the 60% PPH was greater ($P < .05$) than piglets from sows fed the 0% and 80% PPH diets. Also, there was no difference between the 14-day weight of piglets from sows fed the 0% and 40% PPH diets, but both groups were heavier ($P < .05$) than piglets from sows fed the 80% PPH diet. The 21-day weights of piglets from sows fed the 0% and 80% PPH diet did not differ. Based on net weight gain of weaned piglets, it appears that lactation performance of sows on the 60% PPH diet during gestation was improved ($P < .05$) when compared with those fed the 0% and 80% PPH diets. However, differences in sow's lactation performance were attributed to a lower number of weaned piglets at 21 days postpartum (table 2). A trend was observed where sows fed the 60% PPH diet during gestation weaned fewer piglets than sows on the 0%, 40% and 80% PPH diets, however, differences were not statistically significant.

Maternal and placental weights are shown in table 4. The average breeding weight of sows fed the diet containing 60% PPH was greater ($P < .05$) than sows fed the 0%, 40% and 80% PPH diets. Difference in breeding weights was the result initially of experimental randomization. The 110-day gestation, 24-hour postpartum and 21-day postpartum weights of sows fed the 60% PPH were also greater. Although,

Table 4. Effect of Perennial Peanut Hay Diets on Sow Weight Changes During Gestation and Lactation, and Their Placental Weights (Exp. 1)

Item	0% PPH	40% PPH	60% PPH	80% PPH	SE ^a
Sow number	6	6	5	6	
Sow weights, kg					
Breeding	132 ^f	146 ^f	171 ^e	132 ^f	7.17
110 day gestation	165 ^{f,g}	184 ^{e,f}	209 ^e	151 ^g	8.76
24-hr postpartum	155 ^{f,g}	169 ^f	196 ^e	140 ^g	7.93
21-day postpartum	149 ^{f,g}	166 ^{e,f}	185 ^e	134 ^g	8.90
Gestation wt. gain ^b	33 ^e	38 ^e	37 ^e	19 ^f	3.58
Gestation wt. change ^c	23 ^e	23 ^e	25 ^e	8 ^f	2.76
Lactation wt. change ^d	-2	-3	-11	-5	3.77
Placenta wt., kg	2.09	1.94	1.70	1.94	.42

Note: Least-square means.

^aPooled standard error of the LS Mean.

^bGestation wt. gain = breeding wt. to wt. at 110 days of gestation.

^cGestation wt. change = breeding wt. to wt. at 24 hr postpartum.

^dLactation wt. change = 24-hr postpartum wt. to 21-day postpartum wt.

^{e,f,g}LS Means in rows with different superscripts differ ($P < .05$).

differences in maternal weights were present throughout gestation and lactation, the breeding, 110-day gestation, 24-hour postpartum and 21-day postpartum weight of sows fed the 80% PPH diet were significantly lower ($P < .05$) than those fed the 40% and 60% PPH diet. Gestation weight gain and gestation weight change among sows fed the 0%, 40% and 60% PPH diets were significantly ($P < .05$) higher than for sows fed the 80% PPH diet. Lactation weight change and placenta weight did not differ among dietary treatments. These data are in agreement with the findings of Danielson and Noonan, 1975; Pollmann et al., 1979, 1980; and Calvert et al., 1985 who reported a reduction in gestation weight gain and gestation weight change when levels up to 97.5% alfalfa meal were fed during gestation; and with the findings of Pollmann et al., 1980 and Calvert et al., 1985 that when levels up to 95% alfalfa meal were fed during gestation, lactation weight change was not affected.

Experiment 2

The effects of feeding 0% and 80% PPH diets during gestation on litter performance over three parities using 12 sows (6 sows per treatment) are summarized in tables 5 and 6. As in experiment 1, the 80% PPH diet had no effect ($P > .05$) on litter size, piglets born alive, overlaid piglets and piglets alive at days 7, 14 and 21 postpartum, or weaning percentage of piglets for any of the three parities and three parities average (table 5). Although not

statistically significant, there was a tendency for a higher weaning percentage for sows fed the gestation diet containing 80% PPH during parities 1 and 2, and when summarized over all three parities.

Table 6 gives the birth weights and growth performance of piglets at 7, 14 and 21 days postpartum, together with net weight gains from birth to 21 days postpartum. Feeding sows the 80% PPH diet had no effect ($P > .05$) on piglet birth weight, and piglet weights at 7, 14 and 21 days postpartum, or net weight gain of weaned piglets for any of the three parities. The average of the three parities showed that when sows were fed the 80% PPH diet during gestation, piglet weights were lower ($P < .05$) only at 21 days postpartum and that net weight gain of piglets during lactation was not affected by the 80% PPH diet fed during gestation. This observation indicated similar lactation performance for sows in both treatments.

Maternal and placental weights are given in table 7. Body weight at breeding differed ($P < .05$) between sows fed 0% and 80% PPH diets during parity 3 and when summarized over the three parities only. Much of this difference can be attributed to weight change associated with normal growth patterns and the time required to progress through

Table 5. Effect of Perennial Peanut Hay Fed During Gestation On Number Of Piglets Per Litter By Parity (Exp. 2)

Item	Parity 1			2			3			Average ^a		
	0%	80%	PPH	0%	80%	PPH	0%	80%	PPH	0%	80%	PPH
Litters	6	6	6	6	6	6	6	6	6	18	18	18
Litter size	10.7	9.7	9.7	11.7	9.5	9.5	12.8	12.2	11.7	11.7	10.4	10.4
Piglets												
Born alive	9.8	8.8	8.8	11.5	9.5	9.5	10.7	10.8	10.7	10.7	9.7	9.7
Alive, day 7	6.2	7.7	7.7	8.2	8.3	8.3	9.0	8.3	7.8	7.8	8.1	8.1
Alive, day 14	5.8	7.3	7.3	7.7	7.8	7.8	8.8	7.0	7.4	7.4	7.4	7.4
Alive, day 21	5.7	7.3	7.3	7.7	7.8	7.8	8.7	6.3	7.3	7.3	7.2	7.2
Overlaid	.8	.8	.8	1.0	1.0	1.0	.2	2.3	.7	.7	1.4	1.4
Weaned, %	62.7	78.7	78.7	59.8	83.3	83.3	72.4	60.0	64.9	64.9	74.1	74.1

Note: Least-square means.

^aDietary treatment average for three parities.

Table 6. Effect of Perennial Peanut Hay Fed During Gestation on Piglet Weights by Parity (Exp. 2)

Item	Parity 1			2			3			Average		
	0%	80%		0%	80%		0%	80%		0%	80%	
	PPH	PPH		PPH	PPH		PPH	PPH		PPH	PPH	
Litters	6	6		6	6		6	6		18	18	
Piglet wt., kg												
Birth wt.	1.45	1.16		1.40	1.34		1.28	1.32		1.38	1.27	
7 day wt.	2.47	2.26		2.22	2.19		2.14	1.97		2.28	2.14	
14 day wt.	4.13	3.72		3.85	3.55		3.24	2.93		3.74	3.40	
21 day wt.	5.19	4.87		5.44	4.99		5.00	3.99		5.21 ^b	4.62	
Net wt. gain	3.76	3.71		4.13	3.66		3.65	2.67		3.85	3.35	

Note: Least-square means.

^aDietary treatment average for three parities.

^bMeans in rows within parities differ ($P < .05$).

Table 7. Treatment and Parity Effects of Perennial Peanut Hay Fed During Gestation on Sow Weight Change and Placental Weights (Exp. 2)

Item	Parity 1			2			3			Average ^a	
	0%	80%	PPH	0%	80%	PPH	0%	80%	PPH	0%	80%
Sow Number	6	6		6	6		6	6		18	18
Sow Wt., Kg											
Breeding	159	144		194	166		221 ^e	189		192 ^e	166
110 day Gestation	201 ^e	170		240 ^e	204		246 ^e	204		229 ^f	193
24-hr Postpartum	190 ^e	154		228 ^e	183		224 ^e	180		214 ^f	172
21-day Postpartum	185 ^e	153		222 ^e	188		227 ^e	174		211 ^f	172
Gestation Wt. Gain ^b	42 ^e	26		46	38		25	15		38 ^f	26
Gestation Wt. Change ^c	31 ^e	10		34 ^e	17		6	-10		24 ^f	6
Lactation Wt. Change ^d	-3	-1		-6	5		3	-5		-2	0
Placenta Wt., Kg	2.03	1.82		2.73	2.52		3.36	2.83		2.70	2.39

Note: Least-square means.

^aDietary treatment average for four parities (Exp. 1 and Exp. 2).

^bGestation wt. gain = breeding wt. to 110 days of gestation wt.

^cGestation wt. change = breeding wt. to 24-hr post-partum wt.

^dLactation wt. change = 24-hr post-partum wt. to 21-day post-partum wt.

^eLS Means in rows within parities differ (P<.05).

^fLS Means in rows within parities differ (P<.0001).

subsequent reproductive cycles. The 110-day gestation, 24-hour postpartum, 21-day postpartum weight and gestation weight change were significantly higher for sows fed 0% PPH during each parity ($P < .05$) and the average of the three parities ($P < .0001$). Gestation weight gain was significantly higher for the 0% PPH group in parity 1 ($P < .05$) and the average of three parities ($P < .0001$). However, no treatment differences ($P > .05$) were measured for lactation weight change and placental weight during any parity or three parities average.

Experiment 3

The effects of feeding 0% and 80% PPH diets to sows during gestation on litter performance are summarized in tables 8 and 9. Feeding the 80% PPH diet during gestation did not affect the number of piglets per litter, weaning percentage (table 8) or piglet weights (table 9). Maternal and placental weights along with lactation feed intake are given in table 10. Breeding, 110-day gestation and 21-day postpartum weights did not differ between the groups fed 0% and 80% PPH, but weight at 24 hours postpartum was higher ($P < .05$) for the group fed 0% PPH. The gestation weight gain and gestation weight change of sows fed the 0% PPH diet were greater ($P < .0002$) than sows fed the 80% PPH diet. No difference was found between the two dietary groups for lactation weight change and placenta weight. Lactation

Table 8. Effect of Perennial Peanut Hay Fed To Gestating Sows on Number of Piglets Per Litter (Exp. 3)

Item	0% PPH	80% PPH	SE ^a
Litters	9 ^b	10	
Litter size	9.2	10.6	.85
Piglets			
Born alive	8.7	10.4	.80
Alive, day 7	8.3	9.3	.80
Alive, day 14	8.1	9.2	.80
Alive, day 21	8.1	9.2	.80
Overlaid	.1	.5	.24
Weaned, %	92.0	88.6	3.30

Note: Least-square means.

^aPooled standard error of the LS Mean.

^bOne sow aborted at approximately 105 days of gestation.

Table 9. Effect of Perennial Peanut Hay Fed To Gestating Sows on Piglet Weight (Exp. 3)

Item	0% PPH	80% PPH	SE ^a
Litters	9 ^b	10	
Piglet wt., kg			
Birth wt.	1.41	1.29	.05
7 day wt.	2.78	2.64	.06
14 day wt.	4.44	4.46	.30
21 day wt.	6.22	5.57	.23
Net wt. gain	4.81	4.27	.21

Note: Least-square means.

^aPooled standard error of the LS Mean.

^bOne sow aborted at approximately 105 days of gestation.

Table 10. Effect of Perennial Peanut Hay Diets on Sow Weight Change, Placental Weights and Lactation Feed Intake (Exp. 3)

Item	0% PPH	80% PPH	SE ^a
Sow No	9 ^b	10	
Sow weights, kg			
Breeding	162	172	7.44
110 day gestation	211	197	6.10
24-hr postpartum ^f	204	183	6.48
21-day postpartum	194	176	6.66
Gestation wt. gain ^{c,g}	49	26	3.60
Gestation wt. change ^{d,g}	43	11	3.85
Lactation wt. change ^e	-11	-6	2.73
Lactation ADFI, kg ^f	5.86	6.84	.32
Placenta wt., kg	1.93	2.42	.25

Note: Least-square means.

^aPooled standard error of the LS Mean.

^bOne sow aborted at approximately 105 days of gestation.

^cGestation wt. gain = breeding wt. to wt. at 110 days of gestation.

^dGestation wt. change = breeding wt. to wt. at 24-hr postpartum.

^eLactation wt. change = 24-hr postpartum wt. to 21-day postpartum.

^fDiet effect ($P < .05$).

^gDiet effect ($P < .0002$).

average feed intake was greater ($P < .05$) for sows fed the diet containing 80% PPH during gestation. This observation was consistent with findings of Calvert et al., 1985 and Holzgraefe et al., 1986; who reported a greater feed intake during lactation when sows were fed alfalfa meal diets during gestation.

The effect of dietary treatments during gestation on milk composition is summarized in table 11. The 80% PPH diet did not affect the percentage of solids, protein, ash and caloric value of colostrum, but the percentage of fat was increased ($P < .05$) while lactose was decreased ($P < .05$). The higher fat percentage in colostrum of sows fed 80% PPH during gestation is in agreement with the hypothesis that feeding high fiber during gestation should increase the percentage of fat in milk (Holzgraefe et al., 1986). Comparison between dietary groups of milk samples collected at day 7 of lactation indicated that the 80% PPH diet did not affect the percentage of fat, ash or the caloric value but increased ($P < .05$) protein and decreased the percentages of total solids ($P < .05$) and lactose ($P < .05$).

Table 11. Analysis of Milk Samples From Sows Fed Perennial Peanut Hay During Gestation (Exp. 3)

Item	Colostrum			7-Day Milk		
	0%	80%	SE ^a	0%	80%	SE ^a
	PPH	PPH		PPH	PPH	
Sow No.	5	5		9	10	
Solids, %	22.70	23.81	11.11	18.93 ^c	17.94	.28
Fat, %	4.07 ^c	6.62	.70	7.04	6.15	.33
Protein, %	15.45	14.50	1.46	7.48 ^c	8.24	.22
Lactose, %	2.42 ^c	1.87	.17	3.61 ^b	3.02	.06
Ash, %	.76	.78	.02	.80	.79	.02
Energy, kcal/g	1.29	1.43	.07	1.06	1.07	.09

Note: Least-square means.

^aPooled standard error of the LS Mean.

^bDiet effect ($P < .0001$).

^cDiet effect ($P < .05$).

CHAPTER 4
EFFECT OF PERENNIAL PEANUT HAY ON
NUTRIENT UTILIZATION BY GRAVID SOWS

Introduction

Fibrous material which is comprised primarily of cellulose and hemicellulose is digested mainly in the large intestine of the pig by anaerobic microbial fermentation. The volatile fatty acids (VFA) produced are absorbed from the cecum and colon to provide part of the animals energy requirements (Kass et al., 1980b; Rerat et al., 1987; Giusi-Perier et al., 1989).

Utilization of nutrients from dietary fiber by growing-finishing swine has been shown to be minimal. High levels of fiber in swine diets reduce average daily gain and feed utilization (Bohman et al., 1953, 1955; Hanson et al., 1956; Becker et al, 1956; Heitman and Meyer, 1959; Kornegay, 1978; Kass et al., 1980a; Powley et al., 1981; Frank et al., 1983; Lindemann et al., 1986; Pond et al., 1989). The depression in growth has been attributed to a reduction in the concentration of digestible energy as the level of fiber was increased in the diet. However, high fiber, low energy diets fed to sows during gestation has been shown not to affect reproductive performance of sows (Danielson and

Noonan, 1975; Pollmann et al., 1980; Calvert et al., 1985; Pond et al., 1985; Holzgraefe et al., 1986). Of the forages grown in Florida, perennial peanut appears to have a great potential for feeding sows during gestation.

The objective of this study was to determine the effect of feeding an 80% perennial peanut hay diet during gestation on the utilization of dietary nitrogen, energy, ether extract and fiber.

Materials and Methods

Twenty crossbred sows in second gestation with an average initial weight of 166 kg were randomly assigned in equal sized groups at breeding to a diet containing 0% or 80% perennial peanut hay (PPH).

Composition and chemical analyses of diets are presented in tables 12 and 13. Sun-cured PPH was ground through a portable hammer mill¹ (9.0 mm screen) and mixed with other ingredients to obtain the 80% PPH diet. Analysis of the PPH used in this trial is given in tables 14 and 15. Diets were formulated to contain approximately the same amount of crude protein but no attempt was made to equalize metabolizable energy (ME), as shown in table 12. Table 13 shows that the 80% PPH gestation diet contained less crude protein but more crude fiber and fiber constituents than the 0% PPH diet. An ME value of 1190 kcal/kg for perennial

¹Gelb Bros. Mfg., West Bend, WI.

Table 12. Composition of Gestation Diets

Ingredient	Diets ^a	
	0% PPH	80% PPH
Peanut hay ^b		79.6
Corn	81.3	16.0
Soybean meal	15.5	1.5
Def. Phos.	1.8	2.1
Limestone	.6	
Salt	.5	.5
Vitamin Premix ^c	.3	.3
Mineral Premix ^d	.1	.1

Calculated analysis, % (as fed)		
Protein	14.00	14.00
Ca	.85	1.88
P	.65	.65
ME (Mcal/kg)	3.25	1.53

^aPPH = perennial peanut hay.

^bSun-cured perennial peanut hay, ground, (9 mm screen).

^cProvided 7,700 IU vitamin A; 1,100 IU vitamin D₃; 16.5 IU vitamin E; 26.5 mcg vitamin B₁₂; 5.5 mg riboflavin; 33 mg niacin; 22 mg pantothenic acid; 275 mg choline; 4.0 mg menadione; .66 mg folic acid; 2.2 mg pyridoxine; 1.1 mg thiamine; and 110 mcg biotin per kg of finished feed. Courtesy of Hoffman-LaRoche Inc., Nutley, NJ 07110.

^dSupplied 150 mg zinc; 60 mg manganese; 175 mg iron; 17.5 mg copper; 2 mg iodine; and 40 mg calcium per kg of finished feed. Courtesy of J.M. Huber Corporation, Quincy, IL.

Table 13. Chemical Analyses of Gestation Diets

Item ^b	Diets ^a	
	0% PPH	80% PPH
Dry matter, %	90.46	89.62
Crude protein, %	16.18	11.76
Ether extract, %	4.41	3.95
Crude fiber, %	1.94	24.50
Ash, %	6.15	9.00
Fiber constituents, %		
NDF	9.05	42.58
ADF	3.76	36.60
Cellulose	2.96	24.34
Hemicellulose	5.29	5.98
Lignin	0.93	10.60
Gross energy, Mcal/kg	4.29	4.24
Calculated ME, Mcal/kg	3.59	1.72

^aPPH = perennial peanut hay.

^bAll analyses are reported on dry matter basis.

Table 14. Chemical Analyses of Sun-Cured Perennial Peanut Hay

Item ^a	%
Dry Matter	90.49
Crude Protein	12.00
Ether Extract	3.82
Crude Fiber	30.00
Ash	7.69
NDF	52.03
ADF	41.24
Hemicellulose	10.79
Cellulose	28.29
Lignin	11.82
Gross Energy, Mcal/Kg	4.35

^aAll analyses are reported on dry matter basis.

Table 15. Amino Acid and Protein Composition in Selected Samples of Fresh and Sun-Cured Perennial Peanut

Amino Acid ^a	Perennial Peanut	
	Homogenate ^b	Sun-Cured Hay
	----- % Sample -----	
Aspartic Acid	1.24	1.13
Glutamic Acid	1.58	1.23
Histidine	.40	.25
Serine	.65	.50
Arginine	.72	.50
Glycine	.72	.63
Threonine	.59	.48
Alanine	.81	.60
Tyrosine	.55	.43
Methionine	.11	.07
Valine	.74	.59
Phenylalanine	.71	.60
Isoleucine	.59	.49
Leucine	1.10	.89
Lysine	.82	.49
Cysteine	.07	.06
Tryptophan	N.A. ^c	N.A
Crude Protein ^d	14.55	13.30

Note: Analyzed by Woodson-Tenent Laboratories, Inc.,
Memphis, TN 38101.

^aAll analyses are reported on dry matter basis.

^bHomogenized leaves and stems from mature plants.
Lyophilized following homogenization.

^cNot available.

^dKjeldahl procedure.

peanut hay (estimated at approximately 90% of ME of sun-cured alfalfa; NAS, 1971) was used to calculate the overall ME value of the 80% PPH diet. Gross energy content in Mcal/kg was similar for both diets but calculated ME was lower for the 80% PPH diet as a result of the fiber concentration (table 13). The intake of sows was adjusted to provide 127.0 kcal of calculated ME/kg BW^{.75}/day, and feeding level was readjusted biweekly thereafter to accommodate for weight gain during gestation. Because of the difference in the calculated ME of the diets, the average feed intake on a dry matter basis (DMB) was 1.82 and 3.36 kg/day for sows fed the 0% and 80% PPH diets, respectively. Diets were fed in meal form at 0900 and 1800 hr daily from breeding until parturition and water was offered on an ad libitum basis throughout gestation. Sows were penned by experimental diet, in an open-sided shelter with pens on solid concrete floors. Each pen contained gestation crates to allow individual feeding.

At 48 days postcoitum sows were tethered in metabolism crates also located in the open-sided shelter and total feces were collected from 50 to 53 days postcoitum. To facilitate separation of feces and urine, a Foley catheter (size 20, 5cc, balloon type) was inserted into the bladder of all sows 1 day prior to the collection period (Pollmann et al., 1979). Urine was collected in 20-liter plastic

containers to which 100 ml of concentrated HCl had been added to prevent ammonia loss and bacterial contamination. Urine output was strained through glass wool, measured volumetrically and recorded daily. An aliquot comprising 10% of the daily urine void was refrigerated and then aliquots were combined at the end of the trial, and subsamples were taken and frozen at -20°C until analyzed. Feces were collected three times daily, placed in plastic bags and refrigerated. At the end of the collection period, the feces were combined with water to make an homogenate when mixed with a high speed commercial blender. The homogenate was weighed and two 250 g subsamples were transferred into plastic bags and frozen at -20°C until analyzed.

Fecal and urine samples were lyophilized to dryness prior to analysis. Feed samples were collected at the beginning of the collection period and feed or dried fecal samples were ground through a Wiley Mill (1 mm screen) before analysis.

Energy determinations of feed, feces and urine were made by adiabatic calorimetry using a Parr Model 1241 oxygen calorimeter interfaced with a Parr Model 1710 calorimeter controller². Dry matter (DM) determination was conducted as described by AOAC (1980).

²Parr Instruments, Inc., Moline, IL.

Feed, fecal and urinary nitrogen (N) were determined by the Kjeldahl procedure (AOAC, 1980). Ether extract (EE) was determined by using a modified Soxhlet extractor which accommodated multiple one gram samples of feed or feces batched together by treatment and extracted for 24 hr with a 50:50 v/v mixture of ethyl and isopropyl ethers. Neutral detergent fiber (NDF), acid detergent fiber (ADF), permanganate lignin and cellulose in feed and feces samples were determined according to the procedures described by Goering and Van Soest (1970); with NDF determinations modified by α -amylase inclusion (Robertson and Van Soest, 1977) to facilitate filtration. Hemicellulose (HEM) was calculated as ADF subtracted from NDF.

Data were analyzed by the General Linear Model procedure of SAS (Barr et al., 1979) as a complete random design where sows were considered the experimental units.

Results and Discussion

A summary of the energy metabolism data is reported in table 16. The diet containing 80% PPH increased ($P<.0001$) gross energy intake, and fecal and urinary ($P<.004$) energy voids, but it did not affect digestible energy (DE) intake. Total ME intake was higher ($P<.04$) for the 0% PPH diet. Because of the higher fecal and urinary energy voided by sows fed the 80% PPH diet, DE and ME concentrations, expressed as a percentage of intake (table 16) and in Mcal/kg diet (table 17), were lower ($P<.0001$). Similar

Table 16. Effect of 0% and 80% PPH Diets on Energy Metabolism in Gestating Sows

Energy	Diets		SE ^a
	0% PPH	80% PPH	
Intake, Mcal/day ^b	7.79	14.27	.34
Fecal, Mcal/day ^b	1.43	8.33	.36
Urinary, Mcal/day ^c	.23	.37	.03
Digestible, Mcal/day	6.36	5.94	.31
Metabolizable, Mcal/day ^c	6.13	5.30	.26
Digestibility, % ^b	81.72	41.73	.02
Metabolizable, % ^b	78.75	36.96	1.98
ME/DE ratio ^c	96.35	93.37	.54

^aPooled standard error of the mean.

^bMeans differ ($P < .0001$).

^cMeans differ ($P < .04$).

Table 17. Energy Partitioning of Gestation Diets Containing 0% or 80% Perennial Peanut Hay

Energy ^a	Diets		SE ^b
	0% PPH	80% PPH	
Gross, Mcal/kg	4.29	4.24	
Digestible, Mcal/kg ^c	3.50	1.77	.09
Metabolizable, Mcal/kg ^c	3.38	1.57	.08

^aValues reported on dry matter basis.

^bPooled standard error of the mean.

^cMeans differ ($P < .0001$).

results for DE and/or ME percentages have been reported by other researchers when high fiber diets were fed to sows during gestation (Pollmann et al., 1979, 1983; Kornegay, 1981; Holzgraefe et al., 1985b; Calvert et al., 1985; Pond et al., 1986b). The ME in swine diets generally comprises between 90 to 97 percent of DE (NRC, 1979); and the ME values as percentages of DE for 0% and 80% PPH were within that range, although they differed ($P < .04$) from each other. In general, energy balance for all sows allotted in either dietary treatment was adequate as indicated by DE and ME intakes (NRC, 1979).

The actual ME content of the 80% PPH diet was found to be 1.57 Mcal/kg on a dry matter basis instead of the calculated 1.72 Mcal/kg and this difference might have accounted for the lower ME intake of the 80% PPH diet. Using the prediction method described by Pollmann et al. (1979) it is possible to predict the ME value of PPH in the present study. The 0% and 80% PPH diets averaged 3.38 and 1.57 Mcal/kg, respectively. Since the remaining 20% of the 80% PPH diet was accounted for by corn and soybean meal, that percentage of the diet supplied 0.68 Mcal/kg ($.20 \times 3.38$). Therefore, when the .68 Mcal/kg energy supplied by the corn-soybean meal fraction was subtracted from 1.57 Mcal/kg of 80% PPH, the difference was 0.89 Mcal/kg. That value represented the ME contributed by PPH.

Table 18. Effect of 0% and 80% PPH Diets on Nitrogen Metabolism in Gestating Sows.

Nitrogen	Diets		SE ^a
	0% PPH	80% PPH	
Intake, g/day ^b	47.05	63.31	1.56
Fecal, g/day ^b	10.27	39.28	1.88
Urinary, g/day	21.20	14.89	1.71
Digested, g/day ^b	36.78	24.03	1.45
Retention, g/day ^c	15.58	10.24	1.54
Digestibility, % ^b	78.29	38.18	2.45
Retention, % of intake ^c	33.36	16.20	3.34
Retention, % of digested	42.08	41.87	4.05

^aPooled standard error of the mean.

^bMeans differ ($P < .0001$).

^cMeans differ ($P < .03$).

A summary of the nitrogen metabolism data is reported in table 18. Because sows were fed to achieve isocaloric intake, those fed the 80% PPH diet consumed more ($P < .0001$) N and excreted more ($P < .0001$) fecal N than sows on the 0% PPH. Nitrogen digested (g/day and apparent N digestibility) was lower ($P < .0001$) for the 80% PPH group. Urinary nitrogen void was not affected by dietary treatment. Nitrogen retention in g/day and as a percentage of intake was also lower ($P < .03$) for sows fed 80% PPH, but no treatment difference was found for N retention as a function of that digested. Lower N digestibility and/or retention as a percentage of intake have been reported when high fiber diets were fed during gestation (Pollmann et al., 1979,

1983; Young and King, 1981; Kornegay, 1981; Holzgraefe et al., 1985b; Calvert et al., 1985; Pond et al., 1986b). Rate of digesta passage (Farrell and Johnson, 1970; Kass et al., 1980a; Ranvindran et al., 1984; Lindemann et al., 1986; Holzgraefe et al., 1985 a,b) and metabolic fecal nitrogen (Forbes and Hamilton, 1952; Cunningham et al., 1962; Farrel, 1973; Gargallo and Zimmerman, 1981a; Ranvindran et al., 1984; Pollmann et al., 1979; Holzgraefe et al., 1985b) were increased when fibrous materials were fed to swine. Each of these factors had the effect of lowering N digestibility.

The apparent digestibilities and relative quantities digested of DM, EE, and fiber constituents are presented in tables 19 and 20. The 80% PPH diet lowered ($P<.0002$) apparent digestibilities of DM, EE, NDF, ADF, HEM, cellulose and lignin when compared with the 0% PPH diet (table 19). However, because of increased intake sows fed the 80% PPH diet digested more ($P<.0002$) NDF, ADF, cellulose and lignin (g/day) than sows fed the 0% PPH diet (table 20). No differences ($P>.05$) were found in the quantities of DM and HEM digested (table 20). Values for apparent digestibility (table 19) and the quantity of EE digested (table 20) were ($P<.0002$) negative when sows were fed the 80% PPH diet. The lower digestibilities for DM and fiber constituents in the 80% PPH diet reported here are in agreement with results reported by Pollmann et al. (1979, 1983), Zoiopoulos et al. (1983), Holzgraefe et al. (1985b), and Calvert et al.

Table 19. Percentage of Apparent Digestibilities of Dry Matter, Ether Extract and Fiber Constituents in Sows Fed 0% or 80% PPH

Item ^a	0% PPH	80% PPH	SE ^b
Dry matter	82.79	43.88	1.72
Ether extract	57.82	-11.88	5.16
Neutral detergent fiber	56.94	30.40	3.58
Acid detergent fiber	59.37	32.00	3.12
Hemicellulose	55.22	20.66	4.84
Cellulose	58.86	35.67	3.57
Lignin	72.13	29.08	3.47

^aMeans within the row for each item differ ($P < .0002$).

^bPooled standard error of the mean.

Table 20. Relative Quantities in Grams Per Day of Dry Matter, Ether Extract and Fiber Constituents Digested by Sows Fed 0% or 80% PPH

Item ^a	0% PPH	80% PPH	SE ^b
Dry matter	1503.40	1474.00	62.61
Ether extract	46.27	-13.26	5.37
Neutral detergent fiber	93.74	435.32	37.62
Acid detergent fiber	40.63	392.96	31.03
Hemicellulose	53.11	42.36	8.29
Cellulose	31.72	291.89	24.78
Lignin	12.20	103.88	11.90

^aMeans within the row for DM and HEM did not differ ($P > .05$). All others differ ($P < .0002$).

^bPooled standard error of the mean.

(1985); in which DM and the fiber constituents NDF, ADF, HEM and cellulose decreased with increasing levels of dietary fiber intake during gestation. Lignin digestibility has been reported to increase (Kornegay, 1978 and 1981) or decrease (Ranvindran et al., 1984; Pond et al., 1986a; Lindemann et al., 1986) as the level of fiber was increased in the diet of growing-finishing pigs. The digestibility of EE has been reported to decrease when swine were fed high fiber diets (Kornegay, 1978; Pond et al., 1986b). Schneider and Flatt (1975) also confirmed that it is not unusual for EE of the feces to exceed that of the feed and their statement can be used in part to explain the negative EE digestibility of the 80% PPH diet in this experiment. The lower digestion coefficients for the 80% PPH diet were likely caused by elevated dietary fiber level and an accelerated rate of digesta passage (Farrell and Johnson, 1970; Kass et al., 1980a; Ranvindran et al., 1984; Lindemann et al., 1986; Holzgraefe et al., 1985 a,b). With the more rapid transit of digesta, less opportunity existed for both enzymatic and microbial digestion to occur.

CHAPTER 5
EFFECT OF PERENNIAL PEANUT HAY ON THE CONCENTRATION
OF PLASMA CONSTITUENTS DURING GESTATION

Introduction

There is a paucity of published information reporting effects of high fiber diets on concentrations of blood constituents in gestating sows. The majority of published data concerning swine summarize blood constituents of growing-finishing pigs. During gestation, numerous physiological adaptations must be made to ensure that all the needs of growing fetuses are met and that maternal vital functions are maintained (Anderson et al., 1970). Values of blood constituents reported for growing-finishing pigs, therefore, should not be extrapolated to the gestating sow. Addition of fiber to diets fed to growing-finishing pigs has been shown to affect the concentrations of blood glucose (Collings et al., 1979; Pond et al., 1981; Gargallo and Zimmerman, 1981b; Frank et al., 1983), urea nitrogen (Gargallo and Zimmerman, 1980, 1981a, b; Frank et al., 1983) and cholesterol (Collings et al., 1979; Gargallo and Zimmerman, 1981a; Pond et al., 1981).

The objective of this experiment was to evaluate the effects of feeding a diet containing 80% perennial peanut hay to gestating sows on plasma concentrations of glucose, protein, urea nitrogen, lactic acid, total cholesterol, high density lipoprotein (HDL) cholesterol, low density lipoprotein (LDL) cholesterol and triglycerides.

Materials and Methods

Twenty crossbred sows in second gestation with an average initial weight of 166 kg were randomly assigned in equal sized groups at breeding to a diet containing 0% or 80% perennial peanut hay (PPH).

Composition and chemical analyses of diets are presented in tables 21 and 22. Sun-cured PPH was ground through a portable Hammer Mill¹ (9 mm screen) and mixed with other ingredients to obtain the 80% PPH diet. Diets were calculated to contain approximately the same amount of crude protein but no attempt was made to equalize metabolizable energy (ME). Sows in both treatments were fed their assigned diets to provide 127.0 kcal of calculated ME/kg BW^{.75} /day, and the daily ration was readjusted biweekly to accommodate weight gain during gestation. Experimental

¹Gehl Bros. Mfg. Co., West Bend, WI.

Table 21. Composition of Gestation Diets

Ingredient	Diets ^a	
	0% PPH	80% PPH
Peanut hay ^b		79.6
Corn	81.3	16.0
Soybean meal	15.5	1.5
Def. Phos.	1.8	2.1
Limestone	.6	
Salt	.5	.5
Vitamin Premix ^c	.3	.3
Mineral Premix ^d	.1	.1

Calculated analysis, % (as fed)		
Protein	14.00	14.00
Ca	.85	1.88
P	.65	.65
ME (Mcal/kg)	3.25	1.53

^aPPH = perennial peanut hay.

^bSun-cured perennial peanut hay, ground, (9 mm screen).

^cProvided 7,700 IU vitamin A; 1,100 IU vitamin D₃; 16.5 IU vitamin E; 26.5 mcg vitamin B₁₂; 5.5 mg riboflavin; 33 mg niacin; 22 mg pantothenic acid; 275 mg choline; 4.0 mg menadione; .66 mg folic acid; 2.2 pyridoxine; 1.1 mg thiamine; and 110 mcg biotin per kg of finished feed. Courtesy of Hoffman-LaRoche Inc., Nutley, NJ 07110.

^dSupplied 150 mg zinc; 60 mg manganese; 175 mg iron; 17.5 mg copper; 2 mg iodine; and 40 mg calcium per kg of finished feed. Courtesy of J.M. Huber Corporation, Quincy, IL.

Table 22. Chemical Analyses of Gestation Diets

Item ^b	Diets ^a	
	0% PPH	80% PPH
Dry matter, %	90.46	89.62
Crude protein, %	16.18	11.76
Ether extract, %	4.41	3.95
Crude fiber, %	1.94	24.50
Ash, %	6.15	9.00
Fiber constituents, %		
NDF	9.05	42.58
ADF	3.76	36.60
Cellulose	2.96	24.34
Hemicellulose	5.29	5.98
Lignin	0.93	10.60
Gross energy, Mcal/kg	4.29	4.24
Calculated ME, Mcal/kg	3.59	1.72

^aPPH = perennial peanut hay.

^bAll analyses are reported on dry matter basis.

diets were fed in meal form at 0900 and 1800 hr daily from breeding until parturition. Water was supplied ad libitum. Sows were penned by experimental diet in an open-sided shelter with pens on solid concrete floors. Each pen contained gestation crates to facilitate individual feeding.

Blood sample collection was performed on days 0 (prior to breeding), 20, 40, 60, 80 and 100 postcoitum. Thirty millimeters of blood was collected into heparinized tubes via jugular puncture immediately prior to 0900 hr before the morning feeding on each collection day. Fasting blood samples were expected to provide more consistent concentrations of blood metabolites (Pond et al., 1981). Blood was centrifuged at $3000 \times g$ for 10 minutes and the harvested plasma was subdivided into seven equal aliquots which were stored at -20°C until analyzed for concentrations of glucose, protein, urea nitrogen, lactic acid, total cholesterol, HDL-cholesterol and triglycerides.

Plasma glucose concentrations were determined colorimetrically by the glucose oxidase:peroxidase method² using o-dianisidine dihydrochloride as the chromagen acceptor. Plasma protein concentrations were determined by using brilliant blue in the colorimetric method described by Bradford (1976). Plasma cholesterol, HDL-cholesterol,

²The enzymatic colorimetric determination of glucose, Tech. Bull. No. 510. Sigma Chemical Co., St. Louis, MO 63178.

triglycerides, urea nitrogen and lactic acid concentrations were determined colorimetrically using procedures described by, and reagents purchased from Sigma Diagnostics³.

All samples were assayed in duplicate using a Bausch and Lomb Spectronic 21 spectrophotometer⁴. Low density lipoprotein cholesterol in plasma was calculated as: LDL-cholesterol = [total cholesterol] - [HDL-cholesterol] - [triglycerides/5]. Concentrations for each plasma constituent were pooled for day 0 prior to randomization and allotment in order to establish a baseline to evaluate the effect of high fiber diets on plasma constituents at each subsequent collection period.

Data were analyzed by the General Linear Model procedure of SAS (Barr et al., 1979) as a split-plot design in which the whole units were arranged completely at random (Steel and Torrie, 1980). Dietary treatments were considered the whole-plot and the collection period was the sub-plot dietary treatment. Sows were considered the experimental units. The model included diet (0% and 80% PPH), collection period at days 0, 20, 40, 60, 80 and 100

³Sigma Diagnostics Procedures: cholesterol, No. 352; HDL-cholesterol, No. 352-3; urea nitrogen, No. 640; triglycerides, No. 405; and pyruvate/lactate, No. 726-UV/826-UV. Sigma Chemical Co., St. Louis, MO 63178.

⁴Milton Roy Co., Rochester, NY 14625.

postcoitum, and the interaction between diet and collection period. The whole-plot error term was sows within diets and was used to test effects of dietary treatments.

Results and Discussion

The concentrations of plasma constituents in sows fed 0% and 80% PPH diets are presented by collection period in table 23. The overall mean concentrations of glucose, protein, urea nitrogen, cholesterol, LDL-cholesterol and triglycerides in the plasma of sows fed the 0% and 80% PPH diets during gestation did not differ ($P>.05$). The overall mean concentration of lactic acid in plasma of sows fed the 80% PPH diet was higher ($P<.008$) than for sows fed the 0% PPH diet (23.81 vs. 15.53 mg/100 ml). The concentration of HDL-cholesterol in plasma of sows fed the 0% PPH diet was higher ($P<.05$) than for sows fed the 80% PPH diet (29.28 vs. 26.12 mg/100 ml). Plasma values for LDL- and HDL-cholesterol in this experiment are in agreement with values cited by Grummer and Carroll (1988) in which LDL-cholesterol accounts for the majority of the blood cholesterol in pigs. Time trends for changes in the concentration of plasma constituents are reported in table 23 and presented graphically in figures 1 through 7.

Plasma glucose concentration changed quadratically ($P<.0007$) over the collection periods (figure 1) for sows fed 0 and 80% PPH. The major increase in plasma glucose concentration occurred between days 60 and 100 postcoitum

Table 23. Concentrations of Plasma Constituents by Collection Period in Sows Fed 0% or 80% PPH During Gestation.

Plasma Constituent ^a	PPH %	Collection Period				Overall SE			
		0 ^b	20	40	60				
Glucose	0	3.87	78.40	90.55	79.28	86.72	93.35	87.03	
	80		88.06	96.45	92.23	106.55	113.11	98.38	4.64
Protein	0	4.96	3.92	3.67	4.65	5.28	5.24	4.62	
	80		4.81	5.06	5.17	5.12	4.77	4.98	.38
Urea nitrogen	0	12.06	8.43	9.36	10.82	9.05	8.19	9.65	
	80		7.67	9.51	7.77	10.67	10.09	9.63	.57
Lactic acid ^c	0	19.30	11.95	13.77	10.69	11.95	25.54	15.53	
	80		34.68	20.83	19.63	21.19	27.25	23.81	1.96
Total cholesterol	0	111.03	77.80	83.57	86.12	73.63	65.19	82.89	
	80		80.68	77.88	76.36	70.16	62.34	79.74	2.90
HDL-cholesterol ^c	0	40.81	28.75	27.03	26.83	27.02	25.25	29.28	
	80		22.02	24.31	28.30	22.05	19.21	26.12	1.03
LDL-cholesterol	0	58.57	37.65	43.53	48.12	32.30	24.96	40.85	
	80		48.26	40.86	39.62	33.93	32.51	42.29	3.14
Triglycerides	0	58.30	56.99	65.07	55.90	71.53	74.89	63.78	
	80		51.94	63.54	42.20	70.88	53.12	56.66	3.71

Note: Least-square means at 20-day intervals from day 0-100 of gestation.

^aProtein = g/100 ml; all others mg/100 ml.

^bRepresents average for all 20 sows prior to breeding.

^cOverall dietary means differed: Lactic acid ($P<.008$); HDL-Cholesterol ($P<.05$).

for sows fed the diet containing 80% PPH. Although the plasma glucose curve for sows fed the 80% PPH diet was slightly higher than those fed 0% PPH, there was no evidence for heterogeneity of regression ($P > .05$). The mean plasma protein concentration remained constant (4.80 g/100 ml) throughout collection periods and individual means did not differ ($P > .05$) between dietary treatments (table 22). Plasma urea nitrogen concentrations changed quadratically ($P < .002$) over the collection periods (figure 2); however, the magnitude of change was dependent on the dietary treatment, resulting in a dietary treatment x collection period interaction ($P < .003$), and heterogeneity of regression. Sows on the 0% PPH diet experienced a linear ($P < .05$) decline in the concentration of plasma urea nitrogen throughout gestation, whereas, sows on the 80% PPH diet experienced a quadratic ($P < .001$) change explained by a plasma profile where urea nitrogen was lowest during the first 60 days of gestation then increased thereafter.

Plasma lactic acid concentrations changed cubically ($P < .001$) over the collection periods (figure 3); however, the magnitude of the change was dependent on the dietary treatments and resulted in a dietary treatment x collection period interaction ($P < .001$). Sows on the 0% PPH diet experienced a quadratic ($P < .0001$) change in plasma lactic acid in which lactate decreased up to 40 days postcoitum, then increased thereafter, whereas, sows on the 80% PPH diet

experienced a cubic ($P < .005$) change in which plasma lactate increased up to 20 days postcoitum, decreased out to 80 days then increased throughout the remainder of gestation.

Sows in both dietary groups experienced cubic decreases in plasma concentrations of total cholesterol ($P < .0001$), HDL-cholesterol ($P < .0001$) and LDL-cholesterol ($P < .01$) with time as shown in figures 4, 5 and 6, respectively. The pooled means from both dietary treatments indicated that the concentration of plasma triglycerides increased linearly ($P < .02$) over the collection periods (figure 7). Although plasma triglycerides concentration for the 80% PPH group remained unchanged throughout gestation and, there was no evidence of heterogeneity of regression ($P > .05$). The apparent contradiction of these two statements is the result of the highly significant increase in the plasma triglycerides measured in the sows group fed the 0% PPH diet, and the combining of the two data sets for this observation.

The nutrition of the fetus depends on the transfer of nutrients across the placenta from maternal blood. Thus, adequate fetal nutrition depends on adequate levels of circulating nutrients in the maternal blood. Further, the amount of major nutrients (protein, energy and minerals) deposited in the fetus are extremely large during the terminal stage of pregnancy (Pond and Maner, 1984).

The main source of energy for the fetal piglet is glucose derived from maternal blood (Pond and Maner, 1984). The observed increase in the mean plasma glucose concentration throughout gestation reflected the higher maintenance energy requirement of the sow, and the energy requirements of growing fetuses during the last stages of gestation.

Plasma protein concentration from sows fed the 80% PPH diet was constant throughout gestation, while plasma urea nitrogen increased dramatically from about day 60 postcoitum. The higher plasma urea nitrogen measured in sows fed the 80% PPH diet may have reflected tissue protein catabolism and mobilization of amino acids for biosynthesis of fetal tissues and conversion to plasma glucose from gluconeogenesis. These events were necessary to accommodate the greatly accelerated fetal growth during the last third of gestation, and to maintain homeostasis of circulating plasma protein.

Cholesterol is the major sterol in animal tissues and it is an important component of outer cell membranes (Lehninger, 1982). Thus, the lower plasma concentrations of total cholesterol, HDL- and LDL-cholesterol as gestation progressed into the final trimester may indicate the high demand of cholesterol required for fetal tissue synthesis.

The increase in lactic acid observed in figure 3 for sows fed the 80% PPH diet could reflect increased lactate entering peripheral circulation as VFA from intestinal origin during the first 20-30 days postcoitum. Thereafter, plasma lactate was observed to decline out to day 80 postcoitum. A plausible explanation for this occurrence could be lactate utilization for development of adipose and mammary tissues in the sow, and fetal membranes (Harper, 1969).

The constant level in plasma triglycerides that was measured in sows fed the 80% PPH diet could have reflected low dietary fat digestibility or could have resulted from nonfunctional lipogenesis biosynthetic pathways for triglyceride synthesis from plasma VFA.

Further study should be conducted to explain the dynamics of these circulating metabolites absorbed from high fiber diets fed to gestating swine.

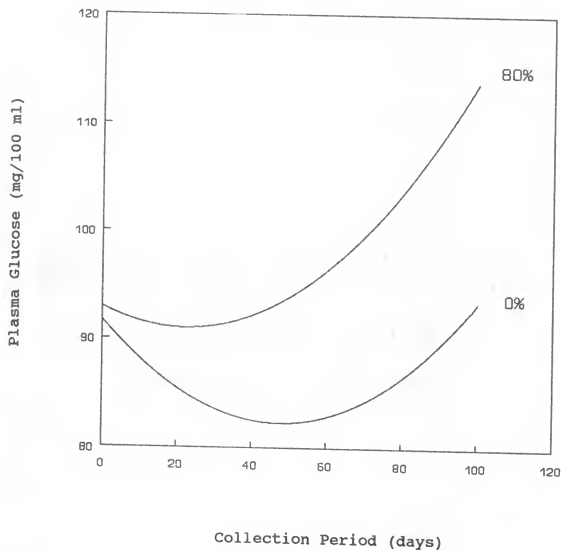


Figure 1. Plasma concentrations of glucose in sows fed gestation diets containing 0% or 80% PPH. Regression equations for curves plotted are given below.

1. 0% $\hat{Y} = 91.69 - 0.393X + 0.0041X^2$
2. 80% $\hat{Y} = 92.94 - 0.171X + 0.0038X^2$

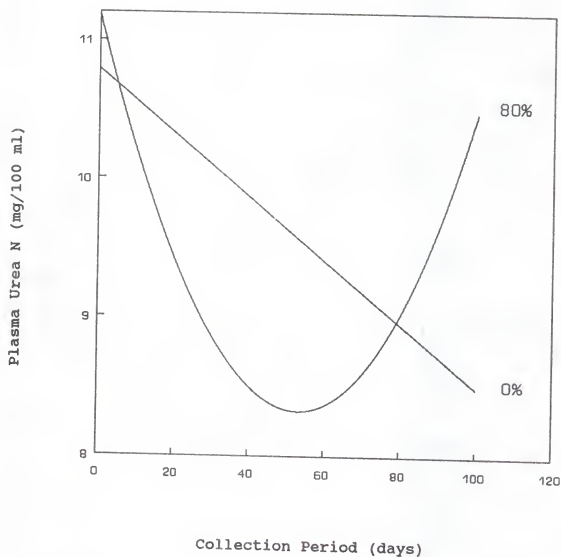


Figure 2. Plasma concentrations of urea nitrogen in sows fed gestation diets containing 0% or 80% PPH. Regression equations for curves plotted are given below.

1. 0% $\hat{Y} = 10.79 - 0.023X$
2. 80% $\hat{Y} = 11.18 - 0.107X + 0.0010X^2$

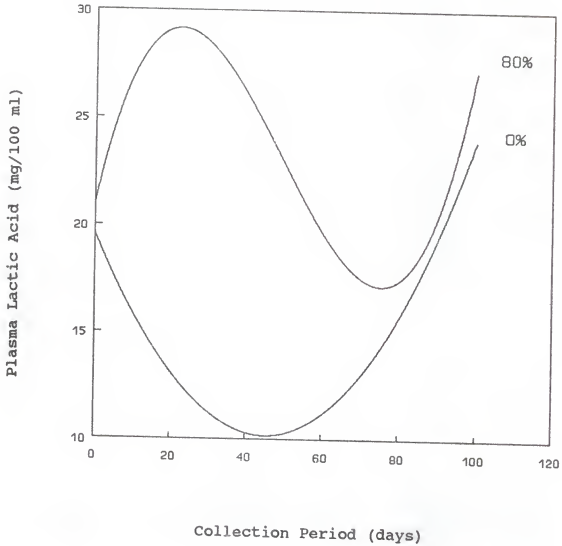


Figure 3. Plasma concentrations of lactic acid in sows fed gestation diets containing 0% or 80% PPH. Regression equations for curves plotted are given below.

1. 0% $\hat{Y} = 19.62 - 0.417X + 0.0046X^2$
2. 80% $\hat{Y} = 20.98 + 0.812X - 0.0235X^2 + 0.00016X^3$

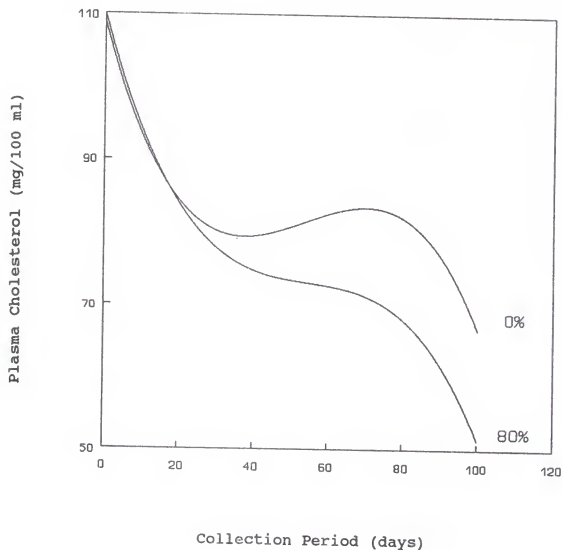


Figure 4. Plasma concentrations of total cholesterol in sows fed gestation diets containing 0% or 80% PPH. Regression equations for curves plotted are given below.

1. 0% $\hat{Y} = 108.85 - 1.903X + 0.0388X^2 - 0.00024X^3$
2. 80% $\hat{Y} = 109.94 - 1.876X + 0.0329X^2 - 0.00020X^3$

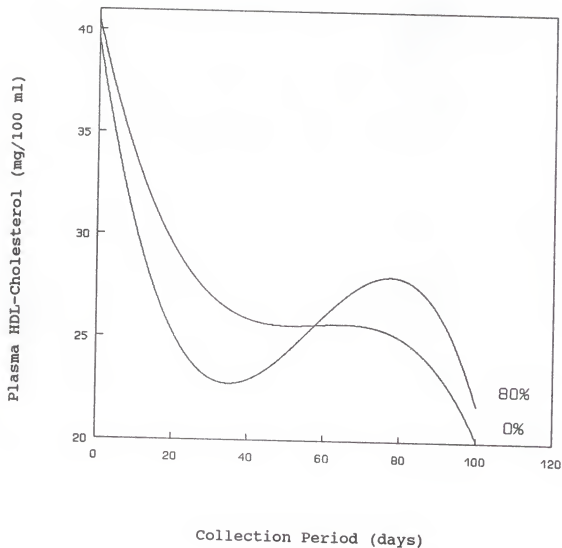


Figure 5. Plasma concentrations of HDL-Cholesterol in sows fed gestation diets containing 0% or 80% PPH. Regression equations for curves plotted are given below.

1. 0% $\hat{Y} = 40.54 - 0.794X + 0.0139X^2 - 0.00008X^3$
2. 80% $\hat{Y} = 39.70 - 1.139X + 0.0236X^2 - 0.00014X^3$

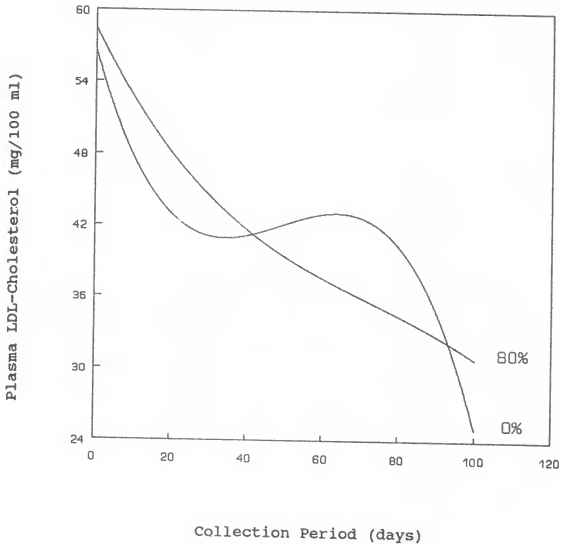


Figure 6. Plasma concentrations of LDL-Cholesterol in sows fed gestation diets containing 0% or 80% PPH. Regression equations for curves plotted are given below.

1. 0% $\hat{Y} = 56.69 - 1.117X + 0.0250X^2 - 0.00017X^3$
2. 80% $\hat{Y} = 58.50 - 0.637X + 0.0066X^2 - 0.00003X^3$

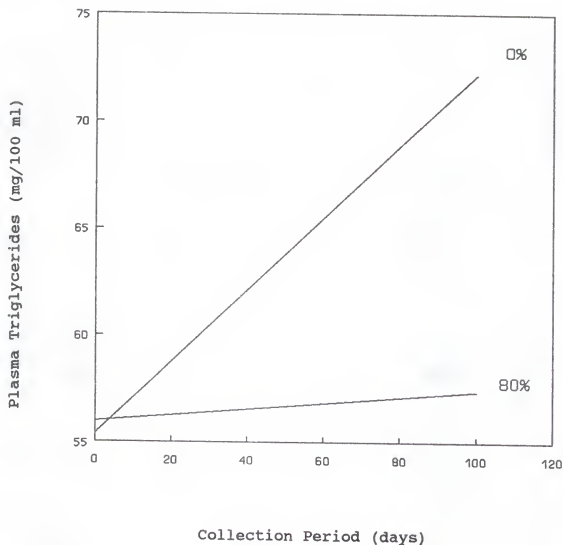


Figure 7. Plasma concentrations of triglycerides in sows fed gestation diets containing 0% or 80% PPH. Regression equations for curves plotted are given below.

1. 0% $\hat{Y} = 55.39 + 0.168X$

2. 80% $\hat{Y} = 55.98 + 0.014X$

CHAPTER 6 SUMMARY AND CONCLUSIONS

Five experiments were conducted to evaluate the use of ground perennial peanut hay (PPH) in sow gestation diets. Experiments 1, 2 and 3 were conducted to (1) determine the maximum level at which PPH could be added to sow gestation diets without affecting reproductive performance, (2) to determine if this maximum level of PPH could be fed during three successive gestations, and (3) to compare the composition of colostrum at day 1 and milk at day 7 of lactation when sows were fed a standard gestation diet or a diet containing PPH during gestation.

The feeding of 0%, 40%, 60% and 80% PPH diets (experiment 1) or 0% and 80% PPH diets (experiments 2 and 3) during gestation had no effect ($P>.05$) on litter size, piglets born alive and piglets alive at 7, 14 and 21 days postpartum. There was a trend for more overlaid piglets from sows fed the 80% PPH diet, but piglet weaning percentage was not affected ($P>.05$) by dietary treatments fed during gestation. No explanation is offered for the low weaning percentages found in experiment 1. It is possible that the level of physical and mental maturity regulating mothering ability during lactation may have been altered by

feeding fibrous diets to primiparous sows during gestation. However, this effect disappeared in multiparous sows during experiments 2 and 3.

The lack of statistical significance in the number of piglets alive from birth to 21 days postpartum, or the weaning percentages in the present study was attributed to the high degree of variation in mothering ability of young sows, the high degree of variation in these traits and the low number of replications in the experimental design.

In experiment 1, the birth weight and 7- and 14-day weights of piglets from sows fed the 0%, 40% and 60% PPH diets were higher ($P < .05$) than piglets from the sows fed 80% PPH diet. The piglet weights at 21 days and net weight gain of weaned piglets from sows fed the 0% and 80% PPH diets did not differ ($P > .05$). However, the 21-day weight and net weight gain of weaned piglets from sows fed the 40% and 60% PPH diets were higher ($P < .05$) than those from sows fed the 80% PPH diet. In experiment 2, feeding sows 0% or 80% PPH diets during gestation had no effect ($P > .05$) on piglet birth weight, and piglet weights at 7, 14 and 21 days postpartum, or net weight gain of weaned piglets for any of the three parities. Similar results were obtained when piglet birth weight, and piglet weights at 7 and 14 days postpartum were summarized over three parities. Although piglets from sows fed the 80% PPH diet during gestation had lower ($P < .05$)

weights at day 21 postpartum, net weight gain of weaned piglets was not affected by gestation dietary treatment.

When data from experiment 3 were considered alone, feeding sows the 80% PPH diet did not affect ($P>.05$) piglet birth weight, and piglet weights at 7, 14 and 21 days postpartum, or net weight gain of weaned piglets during the 21-day lactation period. This observation may suggest that body size and maturity of the sow play an important role in adaptability of the digestive tract to high fiber diets.

Sow weights at breeding, 110 days postcoitum, 24 hr postpartum and 21 days postpartum were significantly lower ($P<.05$) for sows fed the 80% PPH diet. Therefore, gestation weight gain and gestation weight change among sows fed the 0%, 40% and 60% PPH diets (experiment 1) or 0% PPH diet (experiments 2 and 3) were significantly higher ($P<.05$) than for sows fed the 80% PPH diet. A gestation weight gain of 22.0 kg has been reported to be adequate for the normal development of a litter of 12 piglets (Noblet et al., 1990). In the present study, sows fed the 80% PPH diet had an average gestation weight gain of 24.0 kg, therefore, gestation weight gain from sows fed the 80% PPH diet should not have been a limiting factor on sow reproductive performance. Lactation weight change and placenta weight were not affected ($P>.05$) by dietary treatments.

Data for reproductive traits from experiments 1, 2 and 3 represent a number of observations possibly too low to prevent high variability in the reproductive parameters measured (Hays et al., 1969), especially with the very low weaning rates on all treatments in experiment 1. Therefore, low numbers of replications (observations) in reproductive traits was a limiting factor contributing to high variability. This factor resulted in mean differences of some reproductive parameters to have high standard errors; and, coefficients of variation were too great to reach statistical significance .

In experiment 3, lactation feed intake was greater ($P<.05$) for sows fed the 80% PPH diet during gestation. On day 1 of lactation, sows fed the 80% PPH diet displayed increased ($P<.05$) percentage of fat in colostrum while lactose was decreased ($P<.05$). Milk samples collected at day 7 of lactation from sows fed the 80% PPH diet did not differ in fat percentage from those fed the 0% PPH diet, but contained higher ($P<.05$) protein percentage and lower percentages of total solids and lactose ($P<.05$). These data suggest that influences of the high fiber diet fed during gestation on milk fat disappeared quickly when the diet was discontinued at parturition. Therefore, the beneficial effect(s) that high milk fat may have exerted upon piglet survivability early in lactation was fleeting.

In experiment 4, a metabolic study utilizing 20 crossbred sows in gestation was conducted from 50 to 53 days postcoitum to determine the effect of feeding 0% or 80% PPH diets on nutrient utilization. The intake of sows in both treatments was adjusted to provide 127.0 Kcal of calculated ME/kg BW^{.75}/day. Because of the lower ME density of the 80% PPH diet, average daily feed intake (DMB) of sows fed the 80% PPH diet was 3.36 kg/day while those fed the 0% PPH diet consumed an average of 1.82 kg/day. Sows fed the 80% PPH diet had higher ($P < .0001$) gross energy intake but lower ($P < .04$) ME intake than sows fed the 0% PPH diet. Digestible energy intake was not affected ($P > .05$) by dietary treatments. Digestible energy and ME expressed as a percentage of gross energy intake were lower ($P < .0001$) for the 80% PPH diet. This observation might suggest that gestating sows adapted to the 80% PPH diet by increasing feed intake in order to compensate for the lower apparent digestibility coefficients of nutrients and the lower ME associated with the high fiber diet. Sows fed the 80% PPH diet had higher ($P < .0001$) nitrogen intake but lower ($P < .03$) digestible and retained nitrogen than sows on the 0% PPH diet. Digestible nitrogen and retained nitrogen as a percentage of nitrogen intake were lower ($P < .03$) for the 80% PPH diet. Low nitrogen retention from sows on the 80% PPH diet, as observed during the metabolic study, may be a plausible explanation for the lower gestation weight gains.

Feeding the 80% PPH diet reduced ($P < .002$) the apparent digestibilities of dry matter (DM), ether extract (EE), neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose (HEM), cellulose and lignin when compared with the 0% PPH diet. No treatment differences ($P > .05$) were measured between the quantities of DM and HEM digested by the two groups of sows. However, because of greater intake, sows fed the 80% PPH diet digested more quantity of ($P < .0002$) NDF, ADF, cellulose and lignin than those fed the 0% PPH diet. Values for apparent digestibility of EE and quantity of EE digested were negative when sows were fed the 80% PPH diet, and these values resulted from the higher levels of fecal endogenous fat as discussed by Schneider and Flatt (1975).

In experiment 5, 20 crossbred sows in second gestation were utilized to evaluate the effects of feeding a diet containing 0% or 80% PPH to gestating sows on plasma concentrations of glucose, protein, urea nitrogen, lactic acid, total cholesterol, HDL-cholesterol, LDL-cholesterol, and triglycerides. Feeding sows the 80% PPH diet during gestation had no effect ($P > .05$) on the overall plasma mean concentration of glucose, protein, urea nitrogen, cholesterol, LDL-cholesterol, and triglycerides. However, sows fed the 80% PPH diet had higher ($P < .008$) lactic acid and lower HDL-cholesterol ($P < .05$) concentrations in plasma than sows fed the 0% PPH diet.

The observed increase in the mean plasma glucose concentration throughout gestation reflected the high energy supply necessary to satisfy the energy needs of the sow and growing fetuses during the last stages of gestation.

Plasma protein concentration from sows fed the 80% PPH diet kept constant throughout gestation, while plasma urea nitrogen increased dramatically from about day 60 postcoitum. High plasma urea nitrogen may have reflected tissue protein catabolism and mobilization of amino acids to accommodate the greatly accelerated fetal growth that occurs during the last third of gestation. The relatively constant plasma protein concentration measured throughout gestation in sows fed the 80% PPH diet most likely reflected the metabolic response to negative N balance created by lower digestibility of dietary N. Homeostasis of circulating plasma protein further reflected the response to increased demand placed by the combined protein requirements of the sow and her developing fetuses, and the high physiology priority assigned to reproduction. Further, the amount of major nutrients (protein, energy and minerals) deposited in the fetus increase by approximately 3% per day. The absolute amounts of these essential nutrients, therefore, are extremely large during the terminal stage of pregnancy (Pond and Maner, 1984).

The lower plasma concentration of total cholesterol, HDL- and LDL-cholesterol as gestation progressed into the final trimester may indicate the high demand of cholesterol required for fetal tissue synthesis. The observed increase in lactic acid concentration from sows fed the 80% PPH diet could reflect absorption of lactic acid from intestinal VFA during the first 20 days postcoitum. Whereas, the decline in plasma lactic acid out to day 80 postcoitum could indicate lactic acid utilization for development of adipose and mammary tissues in the sow.

The constant level in plasma triglycerides in sows fed the 80% PPH diet could have reflected the negative EE digestibility found in experiment 4, or could have resulted from lack of triglycerides synthesis from plasma free fatty acids and VFA.

Recommendations for Feeding Perennial Peanut Hay to Gestating Swine

Observations from this study suggest that first parity sows can be fed up to 60% PPH during gestation without affecting sow reproductive performance and that lower piglet weights from birth to 21 days postpartum might be expected by feeding 80% PPH to first parity sows. However, 80% PPH may be fed to sows in second or greater parity without affecting reproductive performance if the high fiber diet is discontinued during lactation and is not resumed until the sow is rebred. Increasing digestible energy and other

dietary components to NRC levels at the start of lactation appeared to support requirements for milk synthesis in sows previously fed 80% PPH during gestation. Continuing the dietary regimen until rebreeding may also have induced maximum follicular development and elicited a characteristic "flushing effect" referred to often in the literature as an ovulatory response to increased energy when high energy diets are provided to sows 2-3 weeks prior to breeding.

Grinding perennial peanut hay through a 9 mm screen produced a particle size that increased surface area available to digestive fluids and enzymes. When combined with corn and soybean meal in proportions recommended herein, a bulky but palatable diet was formed. When the 80% diet was offered ad libitum the daily intake necessary to meet calculated energy requirements was very near the sow's maximum daily capacity for intake. Therefore, this feed formulation could be offered in large bulk feeding systems such as round bulk field feeders that require low attendant maintenance. This method of feeding would provide local swine producers, many of whom are part-time farmers, with the alternative of preparing batch feeds and lowering both the frequency of hand feeding and time required to feed gestating sows.

High fiber diets are characteristically bulky and dry. Therefore, feeding high fiber perennial peanut diets requires a readily available source of fresh water. Cup-

type waterers should not be provided because they offer opportunity for feed adhering in the bristles of hair covering the sow's lower jaw to wash into the bowl and accumulate. To circumvent this potential undesirable aspect, nipple waterers should be placed as near the feed source as possible, yet located where water cannot splash into the feed when the sow drinks. Ideally, one waterer should be provided at each feeding station in order to curtail competition for water during feeding. Following these management tips could greatly minimize the requirements to hand feed sows daily and might eliminate requirements for individual feeding stalls used to insure adequate gestation intake by sows of dissimilar age and body weight.

APPENDIX

Table 24. Statistical Analysis For Experiment 1 (Chapter 3).

Dependent Variable: Litter Size

Mean	MSE	Root MSE	R-Square	CV
10.48	9.55	3.09	0.12	29.50
AOV Table				
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	24.206	0.84	0.4864
Error	19	181.533		

Dependent Variable: Piglets Born Alive

Mean	MSE	Root MSE	R-Square	CV
10.09	8.99	3.00	0.12	29.73
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	22.959	0.85	0.4832
Error	19	170.867		

Dependent Variable: Piglets Alive, Day 7

Mean	MSE	Root MSE	R-Square	CV
6.91	10.70	3.27	0.0026	47.32
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	0.526	0.02	0.9970
Error	19	203.300		

Dependent Variable: Piglets Alive, Day 14

Mean	MSE	Root MSE	R-Square	CV
6.52	11.28	3.36	0.02	51.50
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	3.439	0.10	0.9581
Error	19	214.300		

Table 24-continued.

Dependent Variable: Piglets Alive, Day 21

Mean	MSE	Root MSE	R-Square	CV
6.39	11.02	3.32	0.02	51.94
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	4.112	0.12	0.9445
Error	19	209.367		

Dependent Variable: Piglets Overlayed

Mean	MSE	Root MSE	R-Square	CV
1.35	7.13	2.67	0.16	198.11
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	25.751	1.20	0.3353
Error	19	135.467		

Dependent Variable: Piglets Weaned, %

Mean	MSE	Root MSE	R-Square	CV
63.94	887.29	29.79	0.04	46.59
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	711.123	0.27	0.8482
Error	19	16858.508		

Dependent Variable: Piglet Birth Weight, kg

Mean	MSE	Root MSE	R-Square	CV
1.25	0.028	0.17	0.55	13.36
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	0.641	7.68	0.0015
Error	19	0.528		

Table 24-continued.

Dependent Variable: Piglet 7 Day Weight, kg

Mean	MSE	Root MSE	R-Square	CV
2.52	0.060	0.24	0.63	9.68
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	1.659	9.27	0.0009
Error	16	0.955		

Dependent Variable: Piglet 14 Day Weight, kg

Mean	MSE	Root MSE	R-Square	CV
3.79	0.150	0.38	0.62	10.13
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	3.888	8.82	0.0011
Error	16	2.351		

Dependent Variable: Piglet 21 Day Weight, kg

Mean	MSE	Root MSE	R-Square	CV
5.53	0.440	0.66	0.49	12.01
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	6.698	5.07	0.0117
Error	16	7.042		

Dependent Variable: Piglet Net Weight Gain, kg

Mean	MSE	Root MSE	R-Square	CV
4.27	0.411	0.64	0.43	15.00
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	4.925	4.00	0.0266
Error	16	6.568		

Table 24-continued.

Dependent Variable: Sow Breeding Weight, kg

Mean	MSE	Root MSE	R-Square	CV
144.33	309.102	17.58	0.49	12.18
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	5611.161	6.05	0.0045
Error	19	5872.933		

Dependent Variable: Sow Weight at 110 Day of Gestation, kg

Mean	MSE	Root MSE	R-Square	CV
176.00	461.29	21.48	0.54	12.20
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	10164.913	7.35	0.0018
Error	19	8764.545		

Dependent Variable: Sow Weight at 24 Hour Postpartum, kg

Mean	MSE	Root MSE	R-Square	CV
163.83	377.68	19.43	0.56	11.86
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	9250.757	8.16	0.0011
Error	19	7175.906		

Dependent Variable: Sow Weight at Day 21 of Lactation, kg

Mean	MSE	Root MSE	R-Square	CV
158.70	396.334	19.91	0.52	12.54
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	7004.444	5.89	0.0066
Error	16	6341.340		

Table 24-continued.

Dependent Variable: Gestation Weight Gain, kg

Mean	MSE	Root MSE	R-Square	CV
31.66	77.21	8.79	0.47	27.76
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	1315.852	5.68	0.0060
Error	19	1467.055		

Dependent Variable: Gestation Weight Change, kg

Mean	MSE	Root MSE	R-Square	CV
19.51	45.84	6.77	0.55	34.71
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	1075.852	7.82	0.0013
Error	19	870.879		

Dependent Variable: Lactation Weight Change, kg

Mean	MSE	Root MSE	R-Square	CV
-5.23	71.18	8.44	0.18	161.39
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	247.209	1.16	0.3565
Error	16	1138.812		

Dependent Variable: Placenta Weight, kg

Mean	MSE	Root MSE	R-Square	CV
1.93	1.06	1.03	0.02	53.46
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	3	0.430	0.14	0.9379
Error	19	20.170		

Table 25. Statistical Analysis for Experiment 2 (Chapter 3).

Dependent Variable: Litter Size

Mean	MSE	Root MSE	R-Square	CV
11.08	8.31	2.88	0.18	26.00

AOV Table

Source	DF	SS	F-Value	PR>F
Model	5	55.583	1.34	0.2752
Diet	1	14.694	1.77	0.1935
Parity	2	37.167	2.24	0.1242
Diet*Parity	2	3.722	0.22	0.8006
Error	30	249.167		

Dependent Variable: Piglets Born Alive

Mean	MSE	Root MSE	R-Square	CV
10.19	10.09	3.18	0.09	31.17

Source	DF	SS	F-Value	PR>F
Model	5	28.806	0.57	0.7218
Diet	1	8.028	0.80	0.3796
Parity	2	13.722	0.68	0.5144
Diet*Parity	2	7.056	0.35	0.7079
Error	30	302.833		

Dependent Variable: Piglets Alive, Day 7

Mean	MSE	Root MSE	R-Square	CV
7.94	14.92	3.86	0.06	48.62

Source	DF	SS	F-Value	PR>F
Model	5	28.222	0.38	0.8596
Diet	1	1.000	0.07	0.7975
Parity	2	20.056	0.67	0.5182
Diet*Parity	2	7.167	0.24	0.7880
Error	30	447.667		

Table 25-continued.

Dependent Variable: Piglets Alive, Day 14

Mean	MSE	Root MSE	R-Square	CV
7.42	15.11	3.89	0.06	52.40
Source	DF	SS	F-Value	PR>F
Model	5	29.583	0.39	0.8506
Diet	1	0.028	0.00	0.9661
Parity	2	12.667	0.42	0.6613
Diet*Parity	2	16.889	0.56	0.5776
Error	30	453.167		

Dependent Variable: Piglets Alive, Day 21

Mean	MSE	Root MSE	R-Square	CV
7.25	15.92	3.99	0.07	55.03
Source	DF	SS	F-Value	PR>F
Model	5	35.250	0.44	0.8149
Diet	1	0.250	0.02	0.9011
Parity	2	10.500	0.33	0.7216
Diet*Parity	2	24.500	0.77	0.4721
Error	30	477.500		

Dependent Variable: Piglets Overlayed

Mean	MSE	Root MSE	R-Square	CV
1.03	2.86	1.69	0.15	164.58
Source	DF	SS	F-Value	PR>F
Model	5	15.139	1.06	0.4027
Diet	1	4.694	1.64	0.2100
Parity	2	9.389	0.18	0.8325
Diet*Parity	2	9.389	1.64	0.2107
Error	30	85.833		

Table 25-continued.

Dependent Variable: Piglets Weaned, %

Mean	MSE	Root MSE	R-Square	CV
69.50	1066.79	32.66	0.09	47.00
Source	DF	SS	F-Value	PR>F
Model	5	3216.700	0.60	0.6980
Diet	1	748.932	0.70	0.4087
Parity	2	225.130	0.11	0.9002
Diet*Parity	2	2242.638	1.05	0.3621
Error	30	32003.794		

Dependent Variable: Piglet Birth Weight, kg

Mean	MSE	Root MSE	R-Square	CV
1.32	0.05	0.22	0.17	16.84
Source	DF	SS	F-Value	PR>F
Model	5	0.309	1.25	0.3130
Diet	1	0.096	1.93	0.1745
Parity	2	0.036	0.36	0.7004
Diet*Parity	2	0.177	1.79	0.1851
Error	30	1.491		

Dependent Variable: Piglet 7 Day Weight, kg

Mean	MSE	Root MSE	R-Square	CV
2.21	0.15	0.39	0.15	17.51
Source	DF	SS	F-Value	PR>F
Model	5	0.774	1.04	0.4143
Diet	1	0.165	1.11	0.3014
Parity	2	0.552	1.85	0.1754
Diet*Parity	2	0.049	0.16	0.8499
Error	29	4.330		

Table 25-continued.

Dependent Variable: Piglet 14 Day Weight, kg

Mean	MSE	Root MSE	R-Square	CV
3.55	0.49	0.70	0.28	19.67
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Model	5	5.189	2.13	0.0906
Diet	1	0.997	2.05	0.1633
Parity	2	4.356	4.48	0.0205
Diet*Parity	2	0.022	0.02	0.9733
Error	28	13.615		

Dependent Variable: Piglet 21 Day Weight, kg

Mean	MSE	Root MSE	R-Square	CV
4.89	0.64	0.80	0.29	16.42
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Model	5	6.971	2.16	0.0880
Diet	1	2.883	4.47	0.0438
Parity	2	3.053	2.37	0.1127
Diet*Parity	2	0.751	0.58	0.5650
Error	27	17.392		

Dependent Variable: Piglet Net Weight Gain, kg

Mean	MSE	Root MSE	R-Square	CV
3.57	0.58	0.76	0.30	21.38
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Model	5	6.801	2.33	0.0700
Diet	1	2.050	3.51	0.0718
Parity	2	3.245	2.78	0.0799
Diet*Parity	2	1.191	1.02	0.0799
Error	27	15.768		

Table 25-continued.

Dependent Variable: Sow Breeding Weight, kg

Mean	MSE	Root MSE	R-Square	CV
178.89	408.02	20.20	0.66	11.29
Source	DF	SS	F-Value	PR>F
Model	5	23476.648	11.51	0.0001
Diet	1	5751.453	14.10	0.0007
Parity	2	17249.798	21.14	0.0001
Diet*Parity	2	475.397	0.58	0.5647
Error	30	12240.655		

Dependent Variable: Sow Weight at 110 Day of Gestation, kg

Mean	MSE	Root MSE	R-Square	CV
210.92	346.44	18.61	0.70	8.82
Source	DF	SS	F-Value	PR>F
Model	5	23879.752	13.79	0.0001
Diet	1	12083.139	34.88	0.0001
Parity	2	11636.274	16.79	0.0001
Diet*Parity	2	160.339	0.23	0.7948
Error	30	10393.06		

Dependent Variable: Sow Weight at 24-Hour Postpartum, kg

Mean	MSE	Root MSE	R-Square	CV
192.11	367.40	19.17	0.68	9.98
Source	DF	SS	F-Value	PR>F
Model	5	23048.873	12.55	0.0001
Diet	1	15423.107	41.98	0.0001
Parity	2	7873.924	10.72	0.0003
Diet*Parity	2	133.486	0.18	0.8348
Error	29	10654.722		

Table 25-continued.

Dependent Variable: Sow Weight at Day 21 of Lactation, kg

Mean	MSE	Root MSE	R-Square	CV
190.19	282.91	16.82	0.75	8.84
Source	DF	SS	F-Value	PR>F
Model	5	21451.801	15.17	0.0001
Diet	1	12176.314	43.04	0.0001
Parity	2	8001.115	14.14	0.0001
Diet*Parity	2	633.492	1.12	0.3422
Error	25	7072.712		

Dependent Variable: Gestation Weight Gain, kg

Mean	MSE	Root MSE	R-Square	CV
32.03	86.15	9.28	0.62	28.98
Source	DF	SS	F-Value	PR>F
Model	5	4273.651	9.92	0.0001
Diet	1	1161.787	13.49	0.0001
Parity	2	2992.248	17.37	0.0001
Diet*Parity	2	119.616	0.69	0.5073
Error	30	2584.560		

Dependent Variable: Gestation Weight Change, kg

Mean	MSE	Root MSE	R-Square	CV
14.94	71.69	8.47	0.79	56.68
Source	DF	SS	F-Value	PR>F
Model	5	7891.838	22.02	0.0001
Diet	1	2815.076	39.27	0.0001
Parity	2	4402.547	32.80	0.0001
Diet*Parity	2	52.684	0.37	0.6957
Error	29	2078.920		

Table 25-continued.

Dependent Variable: Lactation Weight Change, kg

Mean	MSE	Root MSE	R-Square	CV
-1.01	170.76	13.07	0.10	1291.76
Source	DF	SS	F-Value	PR>F
Model	5	450.645	0.53	0.7530
Diet	1	27.881	0.16	0.6896
Parity	2	10.845	0.03	0.9688
Diet*Parity	2	413.152	1.21	0.3151
Error	25	4719.670		

Dependent Variable: Placenta Weight, kg

Mean	MSE	Root MSE	R-Square	CV
2.52	0.83	0.91	0.28	36.01
Source	DF	SS	F-Value	PR>F
Model	5	8.751	2.12	0.0936
Diet	1	0.806	0.98	0.3320
Parity	2	7.964	4.82	0.0162
Diet*Parity	2	0.185	0.11	0.8945
Error	27	22.293		

Table 26. Statistical Analysis for Experiment 3 (Chapter 3).

Dependent Variable: Litter Size

Mean	MSE	Root MSE	R-Square	CV
9.95	6.59	2.57	0.07	25.80

AOV Table

Source	DF	SS	F-Value	PR>F
Diet	1	8.992	1.37	0.2587
Error	17	111.956		

Dependent Variable: Piglets Born Alive

Mean	MSE	Root MSE	R-Square	CV
9.58	6.02	2.45	0.12	25.62

Source	DF	SS	F-Value	PR>F
Diet	1	14.232	2.36	0.1427
Error	17	102.400		

Dependent Variable: Piglets Alive, Day 7

Mean	MSE	Root MSE	R-Square	CV
8.84	6.12	2.47	0.04	28.00

Source	DF	SS	F-Value	PR>F
Diet	1	4.426	0.72	0.4070
Error	17	104.100		

Dependent Variable: Piglets Alive, Day 14

Mean	MSE	Root MSE	R-Square	CV
8.68	5.91	2.43	0.05	28.00

Source	DF	SS	F-Value	PR>F
Diet	1	5.616	0.95	0.3434
Error	17	100.489		

Table 26-continued.

Dependent Variable: Piglets Alive, Day 21

Mean	MSE	Root MSE	R-Square	CV
8.68	5.91	2.43	0.05	28.00
Source	DF	SS	F-Value	PR>F
Diet	1	5.616	0.95	0.3434
Error	17	100.489		

Dependent Variable: Piglets Overlayed

Mean	MSE	Root MSE	R-Square	CV
0.32	0.55	0.74	0.07	235.33
Source	DF	SS	F-Value	PR>F
Diet	1	0.716	1.30	0.2705
Error	17	9.389		

Dependent Variable: Piglets Weaned, %

Mean	MSE	Root MSE	R-Square	CV
90.19	102.83	10.14	0.03	11.24
Source	DF	SS	F-Value	PR>F
Diet	1	54.697	0.53	0.4757
Error	17	1748.108		

Dependent Variable: Piglet Birth Weight, kg

Mean	MSE	Root MSE	R-Square	CV
1.35	0.02	0.14	0.16	10.61
Source	DF	SS	F-Value	PR>F
Diet	1	0.069	3.34	0.0850
Error	17	0.349		

Table 26-continued.

Dependent Variable: Piglet 7 Day Weight, kg

Mean	MSE	Root MSE	R-Square	CV
2.71	0.04	0.20	0.11	7.24
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	0.083	2.17	0.1589
Error	17	0.653		

Dependent Variable: Piglet 14 Day Weight, kg

Mean	MSE	Root MSE	R-Square	CV
4.45	0.86	0.93	0.0001	20.84
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	0.002	0.002	0.9611
Error	17	14.625		

Dependent Variable: Piglet 21 Day Weight, kg

Mean	MSE	Root MSE	R-Square	CV
5.88	0.53	0.73	0.19	12.38
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	2.053	3.88	0.0655
Error	17	9.001		

Dependent Variable: Piglet Net Weight Gain, kg

Mean	MSE	Root MSE	R-Square	CV
4.53	0.44	0.67	0.15	14.72
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	1.370	3.09	0.0969
Error	17	7.547		

Table 26-continued.

Dependent Variable: Sow Breeding Weight, kg

Mean	MSE	Root MSE	R-Square	CV
166.86	554.03	23.54	0.04	14.11
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	429.940	0.78	0.3900
Error	18	9972.560		

Dependent Variable: Sow Weight At 110 Day of Gestation, kg

Mean	MSE	Root MSE	R-Square	CV
204.20	371.73	19.28	0.13	9.44
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	972.594	2.62	0.1232
Error	18	6691.084		

Dependent Variable: Sow Weight at 24-Hour PostPartum, kg

Mean	MSE	Root MSE	R-Square	CV
193.01	420.61	20.51	0.24	10.63
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	2214.502	5.26	0.0348
Error	17	7150.345		

Dependent Variable: Sow Weight at 21 Day of Lactation, kg

Mean	MSE	Root MSE	R-Square	CV
184.52	399.51	19.99	0.17	10.83
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	1404.953	3.52	0.0780
Error	17	6791.700		

Table 26-continued.

Dependent Variable: Gestation Weight Gain, kg

Mean	MSE	Root MSE	R-Square	CV
37.34	129.41	11.38	0.54	30.47
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	2695.842	20.83	0.0002
Error	18	2329.395		

Dependent Variable: Gestation Weight Change, kg

Mean	MSE	Root MSE	R-Square	CV
26.21	141.35	11.89	0.66	45.35
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	4716.958	33.37	0.0001
Error	17	2402.943		

Dependent Variable: Lactation Weight Change, kg

Mean	MSE	Root MSE	R-Square	CV
-8.49	72.56	8.52	0.07	100.31
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	91.696	1.26	0.2766
Error	17	1233.546		

Dependent Variable: Placenta Weight, kg

Mean	MSE	Root MSE	R-Square	CV
2.19	0.65	0.80	0.09	36.70
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	1.146	1.77	0.2005
Error	17	10.983		

Table 26-continued.

Dependent Variable: Solids in Colostrum, %

Mean	MSE	Root MSE	R-Square	CV
23.25	6.21	2.49	0.06	10.71
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	3.047	0.49	0.5034
Error	8	49.659		

Dependent Variable: Fat in Colostrum, %

Mean	MSE	Root MSE	R-Square	CV
5.36	2.46	1.57	0.46	29.24
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	16.848	6.85	0.0308
Error	8	19.678		

Dependent Variable: Protein in Colostrum, %

Mean	MSE	Root MSE	R-Square	CV
14.98	10.64	3.26	0.03	21.78
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	2.294	0.22	0.6548
Error	8	85.137		

Dependent Variable: Lactose in Colostrum, %

Mean	MSE	Root MSE	R-Square	CV
2.15	0.14	0.37	0.41	17.25
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	0.751	5.48	0.0474
Error	8	1.096		

Table 26-continued.

Dependent Variable: Ash in Colostrum, %

Mean	MSE	Root MSE	R-Square	CV
0.77	0.002	0.04	0.03	5.59
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	0.0005	0.26	0.6207
Error	8	0.0148		

Dependent Variable: Energy in Colostrum, cal/g

Mean	MSE	Root MSE	R-Square	CV
1361	23996.90	154.91	0.20	11.38
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	49420.900	2.06	0.1892
Error	8	191975.200		

Dependent Variable: Solids in Milk, %

Mean	MSE	Root MSE	R-Square	CV
18.41	0.78	0.88	0.26	4.80
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	4.662	5.97	0.0258
Error	17	13.286		

Dependent Variable: Fat in Milk, %

Mean	MSE	Root MSE	R-Square	CV
6.57	1.11	1.05	0.17	16.00
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	3.780	3.42	0.0819
Error	17	18.800		

Table 26-continued.

Dependent Variable: Protein in Milk, %

Mean	MSE	Root MSE	R-Square	CV
7.88	0.47	0.68	0.26	8.66
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	2.775	5.95	0.0259
Error	17	7.921		

Dependent Variable: Lactose in Milk, %

Mean	MSE	Root MSE	R-Square	CV
3.30	0.04	0.20	0.72	5.95
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	1.650	42.74	0.0001
Error	17	0.656		

Dependent Variable: Ash in Milk, %

Mean	MSE	Root MSE	R-Square	CV
0.80	0.005	0.07	0.003	8.84
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	0.0002	0.05	0.8337
Error	17	0.0840		

Dependent Variable: Energy in Milk, cal/g

Mean	MSE	Root MSE	R-Square	CV
1067	76765.43	277.06	0.0004	25.97
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	507.640	0.01	0.9361
Error	17	1305012.344		

Table 27. Statistical Analysis for Chapter 4.

Dependent Variable: Energy Intake, kcal/day

Mean	MSE	Root MSE	R-Square	CV
11029	1122666.30	1059.56	0.91	9.61
AOV Table				

Source	DF	SS	F-Value	PR>F
Diet	1	209648656.7	186.74	0.0001
Error	18	20207994.2		

Dependent Variable: Fecal Energy, kcal/day

Mean	MSE	Root MSE	R-Square	CV
4878	1292747.9	1136.99	0.91	23.31

Source	DF	SS	F-Value	PR>F
Diet	1	237971782.3	184.0	0.0001
Error	18	23269462.7		

Dependent Variable: Urinary Energy, kcal/day

Mean	MSE	Root MSE	R-Square	CV
290	7354.05	85.76	0.43	29.56

Source	DF	SS	F-Value	PR>F
Diet	1	82966.10	11.28	0.0043
Error	15	110310.67		

Dependent Variable: Digestible Energy, kcal/day

Mean	MSE	Root MSE	R-Square	CV
6151	949594.68	974.47	0.05	15.84

Source	DF	SS	F-Value	PR>F
Diet	1	896969.764	0.94	0.3440
Error	18	17092704.264		

Table 27-continued.

Dependent Variable: Metabolizable Energy, kcal/day

Mean	MSE	Root MSE	R-Square	CV
5789	542739.56	736.71	0.26	12.73
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	2850964.52	5.25	0.0368
Error	15	8141093.42		

Dependent Variable: Energy Digestibility, %

Mean	MSE	Root MSE	R-Square	CV
61.73	43.63	6.61	0.91	10.70
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	7996.989	183.30	0.0001
Error	18	785.296		

Dependent Variable: Metabolizable Energy, %

Mean	MSE	Root MSE	R-Square	CV
61.54	32.29	5.68	0.94	9.23
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	7189.942	222.66	0.0001
Error	15	484.377		

Dependent Variable: ME/DE Ratio

Mean	MSE	Root MSE	R-Square	CV
95.12	2.43	1.56	0.50	1.64
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	36.568	15.04	0.0015
Error	15	36.462		

Table 27-continued.

Dependent Variable: Digestible Energy, kcal/kg diet

Mean	MSE	Root MSE	R-Square	CV
2636	78615.95	280.39	0.91	10.63
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	15035360.29	191.25	0.0001
Error	18	1415087.17		

Dependent Variable: Metabolizable Energy, kcal/kg diet

Mean	MSE	Root MSE	R-Square	CV
2631	58283.47	241.42	0.94	9.18
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	13471462.41	231.14	0.0001
Error	15	874252.08		

Dependent Variable: Nitrogen Intake, g/day

Mean	MSE	Root MSE	R-Square	CV
55.18	24.34	4.93	0.75	8.94
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	1322.302	54.32	0.0001
Error	18	438.204		

Dependent Variable: Fecal Nitrogen, g/day

Mean	MSE	Root MSE	R-Square	CV
24.78	35.49	5.96	0.87	24.04
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	4209.358	118.62	0.0001
Error	18	638.736		

Table 27-continued.

Dependent Variable: Urinary Nitrogen, g/day

Mean	MSE	Root MSE	R-Square	CV
18.60	24.24	4.92	0.31	26.47
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	164.030	6.77	0.0200
Error	15	363.551		

Dependent Variable: Nitrogen Digested, g/day

Mean	MSE	Root MSE	R-Square	CV
30.40	20.93	4.58	0.68	15.05
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	813.168	38.85	0.0001
Error	18	376.758		

Dependent Variable: Nitrogen Retention, g/day

Mean	MSE	Root MSE	R-Square	CV
13.38	19.59	4.43	0.29	33.07
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	117.459	6.00	0.0271
Error	15	293.778		

Dependent Variable: Nitrogen Digestibility, %

Mean	MSE	Root MSE	R-Square	CV
58.24	60.98	7.81	0.88	13.41
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	8044.18	131.91	0.0001
Error	18	1097.69		

Table 27-continued.

Dependent Variable: Nitrogen Retention, % (of intake)

Mean	MSE	Root MSE	R-Square	CV
26.30	92.50	9.62	0.47	36.58
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	1212.518	13.11	0.0025
Error	15	1387.541		

Dependent Variable: Nitrogen Retention, % (of digested)

Mean	MSE	Root MSE	R-Square	CV
41.99	161.68	12.72	0.00007	30.28
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	0.174	0.00	0.9743
Error	15	2425.237		

Dependent Variable: Dry Matter Digestibility, %

Mean	MSE	Root MSE	R-Square	CV
63.33	29.52	5.43	0.93	8.58
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	7568.866	256.43	0.0001
Error	18	531.292		

Dependent Variable: Ether Extract Digestibility, %

Mean	MSE	Root MSE	R-Square	CV
22.97	266.63	16.33	0.84	71.08
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	24288.742	91.10	0.0001
Error	18	4799.251		

Table 27-continued.

Dependent Variable: NDF Digestibility, %

Mean	MSE	Root MSE	R-Square	CV
43.67	128.24	11.32	0.60	25.93
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	3522.205	27.47	0.0001
Error	18	2308.311		

Dependent Variable: ADF Digestibility, %

Mean	MSE	Root MSE	R-Square	CV
45.68	97.16	9.86	0.68	21.58
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	3746.387	38.56	0.0001
Error	18	1748.964		

Dependent Variable: Hemicellulose Digestibility, %

Mean	MSE	Root MSE	R-Square	CV
37.94	234.42	15.31	0.59	40.35
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	5971.932	25.48	0.0001
Error	18	4219.505		

Dependent Variable: Cellulose Digestibility, %

Mean	MSE	Root MSE	R-Square	CV
47.27	128.15	11.32	0.54	23.95
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	2688.162	20.98	0.0002
Error	18	2306.711		

Table 27-continued.

Dependent Variable: Lignin Digestibility, %

Mean	MSE	Root MSE	R-Square	CV
50.61	120.99	11.00	0.81	21.74
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	9264.662	76.57	0.0001
Error	18	2177.897		

Dependent Variable: Dry Matter Digested, g/day

Mean	MSE	Root MSE	R-Square	CV
1488.65	39210.25	198.02	0.006	13.30
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	4333.274	0.11	0.7434
Error	18	705784.518		

Dependent Variable: Ether Extract Digested, g/day

Mean	MSE	Root MSE	R-Square	CV
16.50	288.00	16.97	0.77	102.82
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	17722.891	61.54	0.0001
Error	18	5184.023		

Dependent Variable: NDF Digested, g/day

Mean	MSE	Root MSE	R-Square	CV
264.53	14155.58	118.98	0.70	44.98
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	583384.293	41.21	0.0001
Error	18	254800.397		

Table 27-continued.

Dependent Variable: ADF Digested, g/day

Mean	MSE	Root MSE	R-Square	CV
216.79	9628.66	98.13	0.78	45.26
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	620678.943	64.46	0.0001
Error	18	173315.842		

Dependent Variable: Hemicellulose Digested, g/day

Mean	MSE	Root MSE	R-Square	CV
47.73	687.97	26.23	0.04	54.95
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	577.721	0.84	0.3716
Error	18	12383.429		

Dependent Variable: Cellulose Digested, g/day

Mean	MSE	Root MSE	R-Square	CV
161.81	6140.26	78.36	0.75	48.43
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	338446.021	55.12	0.0001
Error	18	110524.652		

Dependent Variable: Lignin Digested, g/day

Mean	MSE	Root MSE	R-Square	CV
58.04	1417.96	37.66	0.62	64.88
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Diet	1	42021.611	29.64	0.0001
Error	18	25523.314		

Table 28. Statistical Analysis For Chapter 5.

Dependent Variable^a: Plasma Glucose, mg/100 ml

Mean	MSE	Root MSE	R-Square	CV
92.70	150.74	12.28	0.71	13.24
AOV Table				
Source	DF	SS	F-Value	PR>F
Model	29	34023.985	7.78	0.0001
Diet	1	3865.016	2.99	0.1011
Sow (Diet)	18	23301.512	8.59	0.0001
Period	5	5324.782	7.06	0.0001
Diet*Period	5	1532.676	2.03	0.0814
Error	90	13566.978		

Dependent Variable: Plasma Protein, g/100 ml

Mean	MSE	Root MSE	R-Square	CV
4.80	1.27	1.13	0.62	23.44
Source	DF	SS	F-Value	PR>F
Model	29	182.885	4.98	0.0001
Diet	1	3.939	0.46	0.5065
Sow (Diet)	18	154.298	6.77	0.0001
Period	5	12.444	1.97	0.0913
Diet*Period	5	12.203	1.93	0.0974
Error	90	113.942		

Dependent Variable: Plasma Urea Nitrogen, mg/100 ml

Mean	MSE	Root MSE	R-Square	CV
9.64	4.04	2.01	0.63	20.86
Source	DF	SS	F-Value	PR>F
Model	29	611.072	5.21	0.0001
Diet	1	0.015	0.00	0.9780
Sow (Diet)	18	355.849	4.89	0.0001
Period	5	174.432	8.63	0.0001
Diet*Period	5	80.776	4.00	0.0026
Error	90	363.829		

^aMean square of sow (diet) was used to test the effect of diet for every dependent variable.

Table 28-continued.

Dependent Variable: Plasma Lactic Acid, mg/100 ml

Mean	MSE	Root MSE	R-Square	CV
19.67	69.69	8.35	0.61	42.44
Source	DF	SS	F-Value	PR>F
Model	29	9700.302	4.80	0.0001
Diet	1	2056.752	8.93	0.0079
Sow (Diet)	18	4144.296	3.30	0.0001
Period	5	1883.637	5.41	0.0002
Diet*Period	5	1615.616	4.64	0.0008
Error	90	6272.495		

Dependent Variable: Plasma Cholesterol, mg/100 ml

Mean	MSE	Root MSE	R-Square	CV
81.32	71.98	8.48	0.85	10.43
Source	DF	SS	F-Value	PR>F
Model	29	35567.758	17.04	0.0001
Diet	1	297.612	0.59	0.4527
Sow (Diet)	18	9092.999	7.02	0.0001
Period	5	25693.768	71.39	0.0001
Diet*Period	5	483.378	1.34	0.2535
Error	90	6478.071		

Dependent Variable: Plasma HDL-Cholesterol, mg/100 ml

Mean	MSE	Root MSE	R-Square	CV
27.70	48.48	6.96	0.58	25.14
Source	DF	SS	F-Value	PR>F
Model	29	6144.299	4.37	0.0001
Diet	1	300.390	4.74	0.0429
Sow (Diet)	18	1139.839	1.31	0.2033
Period	5	4424.363	18.25	0.0001
Diet*Period	5	279.707	1.15	0.3382
Error	90	4363.349		

Table 28-continued.

Dependent Variable: Plasma LDL-Cholesterol, mg/100 ml

Mean	MSE	Root MSE	R-Square	CV
41.57	130.75	11.43	0.66	27.51
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Model	29	22540.982	5.94	0.0001
Diet	1	62.012	0.11	0.7496
Sow (Diet)	18	10627.263	4.52	0.0001
Period	5	10655.730	16.30	0.0001
Diet*Period	5	1195.977	1.83	0.1150
Error	90	11767.823		

Dependent Variable: Plasma Triglycerides, mg/100 ml

Mean	MSE	Root MSE	R-Square	CV
60.22	187.29	13.69	0.59	22.72
<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>F-Value</u>	<u>PR>F</u>
Model	29	24541.540	4.52	0.0001
Diet	1	1518.839	1.84	0.1913
Sow (Diet)	18	14827.563	4.40	0.0001
Period	5	6265.176	6.69	0.0001
Diet*Period	5	1929.962	2.06	0.0776
Error	90	16855.651		

LITERATURE CITED

- Anderson, D.M., F.W.H. Elsley and I. McDonald. 1970. Blood volume changes during pregnancy and lactation of sows. *Quat. J. Exp. Physiol.* 55:293.
- Association of Official Analytical Chemists (AOAC). 1980. *Official Methods of Analysis* (13th Ed.). AOAC, Washington, DC.
- Atherton, H.V. and J.A. Newlander. 1977. *Chemistry and Testing of Dairy Products* (4th Ed). AVI Publishing Company, Inc., Westport, CT.
- Atinmo, T., C. Baldijao, W.G. Pond and R.H. Barnes. 1976. Prenatal and postnatal protein malnutrition in pigs: Effects on growth rate, serum protein and albumin. *J. Anim. Sci.* 43:606.
- Ballinger, C.E. 1939. Pasture consumption by sows. *New Zealand J. Agr. Res.* 59:117.
- Ballinger, C.E. 1944. Nutrition of breeding sows. *New Zealand J. Agr. Res.* 69:101.
- Barr, A.J., J.H. Goodnight, J.P. Sall, W.H. Blair and D. M. Chilko. 1979. *SAS User's Guide. Statistical Analysis System Institute, Inc., Cary, NC.*
- Becker, D.E., L.J. Hanson, A.H. Jensen, S.W. Terrill and H.W. Norton. 1956. Dehydrated alfalfa meal as dietary ingredient for swine. *J. Anim. Sci.* 15:820.
- Blickensderfer, C.B., H.J. Haynsworth and R.D. Roush. 1964. Wild peanuts is promising forage legume in Florida. *Crops and Soils* 17(2):19.
- Bogdan, A.V. 1977. *Tropical pasture and fodder plants. Trop. Agric. Series.* Longman Group Limited, London, England. p. 321-322.
- Bohman, V.R., J.E. Hunter and J. McCormick. 1955. The effect of graded levels of alfalfa and aureomycin upon growing-fattening swine. *J. Anim. Sci.* 14:499.

- Bohman, V.R., J.F. Kidwell and J.A. McCormick. 1953. High levels of alfalfa in the rations of growing-fattening swine. *J. Anim. Sci.* 12:876.
- Boyd, R.D., B.D. Moser, E.R. Peo, Jr. and P.J. Cunningham. 1978. Effect of energy source prior to parturition and during lactation on piglet survival and growth and on milk lipids. *J. Anim. Sci.* 47:883.
- Boyd, R.D., B.D. Moser, E.R. Peo, Jr., A.J. Lewis and R.K. Johnson. 1982. Effect of tallow and choline chloride addition to the diet of sows on milk composition, milk yield and preweaning pig performance. *J. Anim. Sci.* 54:1.
- Bradford, M.M. 1976. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein dye binding. *Anal. Biochem.* 72:248.
- Breman, J.W. 1980. Forage growth and quality of Florigrade perennial peanut (*Arachis glabrata* Benth.) under six clipping regimens. Master's Thesis. Univ. of Florida.
- Calvert, C.C., N.C. Steele and R.W. Rosebrough. 1985. Digestibility of fiber components and reproductive performance of sows fed high levels of alfalfa meal. *J. Anim. Sci.* 61:595.
- Chandler, P.T. 1978. Roughage and fiber. In: C.J. Wilcox and H.H. Van Horn (Eds.). *Large Herd Management*. University Press of Florida, Gainesville.
- Coffey, M.T., J.A. Yates and G.E. Combs. 1987. Effects of feeding sows fat or fructose during late gestation and lactation. *J. Anim. Sci.* 65:1249.
- Collings, G.F., J.P. Erickson, M.T. Yokoyama and E.R. Miller. 1979. Effect of wheat middlings on fiber digestibility, serum cholesterol and glucose and fecal bile acids in pigs. *J. Anim. Sci.* 49:528.
- Conrad, J.H. and W.M. Beeson. 1954. Grass silage and corn silage as feed for brood sows. *Purdue Univ. Agr. Exp. Stn. Mimeo A.H.-133*.
- Conrad, J.H. and W.M. Beeson. 1955. Corn silage as a feed for brood sows. *Purdue Univ. Agr. Exp. Stn. Mimeo A.H.-151*.

- Conrad, J.H. and W.M. Beeson. 1956. A comparison of ground corn cobs and alfalfa meal for self-feeding bred gilts. Purdue Univ. Agr. Exp. Stn. Mimeo A.H.-181.
- Crenshaw, M.A. and D.M. Danielson. 1985. Raw soybeans for gestating swine. *J. Anim. Sci.* 60:163.
- Cunningham, H.M., D.W. Friend and J.W.G. Nicholson. 1962. The effect of age, body weight, feed intake and adaptability of pigs on the digestibility and nutritive value of cellulose. *Can. J. Anim. Sci.* 42:167.
- Danielson, D.M. and J.J. Noonan. 1975. Roughages in swine gestation diets. *J. Anim. Sci.* 41:94.
- De Pape, J.G., W.H. Burkett and A.E. Flower. 1953. Dehydrated alfalfa and antibiotic supplements in gestation-lactation rations for swine. *J. Anim. Sci.* 12:77.
- Ehle, F.R., J.L. Jeraci, J.B. Robertson and P.J. Van Soest. 1982. The influence of dietary fiber on digestibility, rate of passage and gastrointestinal fermentation in pigs. *J. Anim. Sci.* 55:1071.
- Eyles, D.E. 1959. Feeding and management of pregnant sows on pasture. *J. Br. Soc. Anim. Prod.* 1:41.
- Farrell, D.J. 1973. Digestibility by pigs of the major chemical components of diets high in plant cell-wall constituents. *Anim. Prod.* 16:43.
- Farrell, D.J. and K.A. Johnson. 1970. Utilization of cellulose by pigs and its effects on caecal function. *Anim. Prod.* 14:209.
- Forbes, R.M. and T.S. Hamilton. 1952. The utilization of certain cellulosic materials by swine. *J. Anim. Sci.* 11:480.
- Foster, J.R. 1973. Forages for swine and poultry. In: Heath, Metcalfe and Barnes (eds.) *Forages - The Science of Grassland Agriculture*. Iowa State Univ. Press, Ames, IA.
- Franca-Dantas, M.S. 1982. Establishment of 'Florigraze' rhizoma peanut (*Arachis glabrata* Benth.) intercropped with corn, wheat and sunflower. Ph.D. Dissertation. Univ. of Florida.

- Frank, G.R., F.X. Aherne and A.H. Jensen. 1983. A study of the relationship between performance and dietary component digestibilities by swine fed different levels of dietary fiber. *J. Anim. Sci.* 57:645.
- Friend, D.W. 1974. Effect on the performance of pigs from birth to market weight of adding fat to the lactation diet of their dams. *J. Anim. Sci.* 39:1073.
- Friend, D.W., J.W.G. Nicholson and H.M. Cunningham. 1964. Volatile fatty acid and lactic acid content of pig blood. *Can. J. Anim. Sci.* 44:303.
- Friendship, R.M., J.H. Lumsden, I. McMillan and M.R. Wilson. 1984. Hematology and biochemistry reference for Ontario swine. *Can. J. Comp. Med.* 48:390.
- Gargallo, J. and D.R. Zimmerman. 1980. Effects of dietary cellulose and neomycin on function of the cecum of pigs. *J. Anim. Sci.* 51:121.
- Gargallo, J. and D.R. Zimmerman. 1981a. Effects of dietary cellulose levels on intact and cecectomized pigs. *J. Anim. Sci.* 53:395.
- Gargallo, J. and D.R. Zimmerman. 1981b. Effect of sunflower hulls on large intestine function in finishing swine. *J. Anim. Sci.* 53:1286.
- Giusi-Perier, A., M. Fiszlewicz and A. Rerat. 1989. Influence of diet composition on intestinal volatile fatty acid and nutrient absorption in unanesthetized pigs. *J. Anim. Sci.* 67:386.
- Goering, H.K. and P.J. Van Soest. 1970. Forage fiber analyses (apparatus, reagents, procedures and some applications). ARS, USDA Agr. Handbook No. 379, Washington, DC.
- Gregory, M.P. and W.C. Gregory. 1979. Exotic germplasm of Arachis L. inter-specific hybrids. *J. Heredity.* 70:185.
- Gregory, W.C. and M.P. Gregory. 1976. Groundnut Arachis hypogaea (Leguminosae-Papilionoideae) In N.W. Simmonds (Ed.) Evolution of Crop Plants. Longman Group Ltd., London, England.
- Grummer, R.R. and D.J. Carroll. 1988. A review of lipoprotein cholesterol metabolism: Importance to ovarian function. *J. Anim. Sci.* 66:3160.

- Hanson, L.J., D.E. Becker, S.W. Terrill, A.H. Jensen and H.W. Norton. 1956. The inhibitory effect of dehydrated alfalfa meal in the diet of swine. *J. Anim. Sci.* 15:830.
- Harper, H.A. 1969. Review of Physiological Chemistry. Lange Medical Publications, Los Altos, CA.
- Hays, V.W., D.D. Kratzer, V.C. Speer, R.J. Bunch and G.L. Cromwell. 1969. Variability in litter size and birthweight of pigs as it relates to needed replications. *J. Anim. Sci.* 29:136 (Abstr.).
- Heitman, H. and J.H. Meyer. 1959. Alfalfa meal as a source of energy by swine. *J. Anim. Sci.* 18:796.
- Herman, F.J. 1954. A synopsis of the genus *Arachis*. USDA Agricultural Monograph. No. 19. 26 p.
- Hoagland, J.M., H.W. Jones and R.A. Pickett. 1963. Haylage gestation ration for sows and gilts. *Purdue Univ. Res. Prog. Rept.* 75.
- Holy Bible. Genesis 1:29,30. King James Version.
- Holzgraefe, D.P., G.C. Fahey, Jr. and A.H. Jensen. 1985a. Influence of dietary alfalfa:orchardgrass hay and lasalocid on in vitro estimates of dry matter digestibility and volatile fatty acid concentrations of cecal contents and rate of digesta passage in sows. *J. Anim. Sci.* 60:1235.
- Holzgraefe, D.P., G.C. Fahey, Jr., A.H. Jensen and L.L. Berger. 1985b. Effects of dietary alfalfa:orchard-grass hay and lasalocid on nutrient utilization by gravid sows. *J. Anim. Sci.* 60:1247.
- Holzgraefe, D.P., A.H. Jensen, G.C. Fahey, Jr. and R.R. Grummer. 1986. Effects of dietary alfalfa-orchardgrass hay and lasalocid on sow reproductive performance. *J. Anim. Sci.* 62:1145.
- Imoto, S. and S. Namioka. 1978. VFA production in the pig large intestine. *J. Anim. Sci.* 47:467.
- Johnson, C.W., V.C. Speer, G.C. Ashton, C.C. Culbertson and D.V. Catron. 1957. Supplementary plan of nutrition for sows fed corn silage. *J. Anim. Sci.* 16:600.

- Kass, M.L., P.J. Van Soest, and W.G. Pond. 1980b. Utilization of dietary fiber from alfalfa by growing swine. II: Volatile fatty acid concentrations in and disappearance from the gastrointestinal tract. *J. Anim. Sci.* 50:192.
- Kass, M.L., P.J. Van Soest, W.G. Pond, B. Lewis and R.E. McDowell. 1980a. Utilization of dietary fiber from alfalfa by growing swine. I: Apparent digestibility of diet components in specific segments of the gastrointestinal tract. *J. Anim. Sci.* 50:175.
- Keys, J.E., P.J. Van Soest and E.P. Young. 1969. Comparative study of the digestibility of forage cellulose and hemicellulose in ruminants and nonruminants. *J. Anim. Sci.* 29:11.
- Keys, J.E., P.J. Van Soest and E.P. Young. 1970. Effect of increasing dietary cell wall content on the digestibility of hemicellulose and cellulose in swine and rats. *J. Anim. Sci.* 31:1172.
- Klobasa, F., E. Werhahn and J.E. Butler. 1987. Composition of sow milk during lactation. *J. Anim. Sci.* 64:1458.
- Kornegay, E.T. 1978. Feeding value and digestibility of soybean hulls for swine. *J. Anim. Sci.* 47:1272.
- Kornegay, E.T. 1981. Soybean hull digestibility by sows and feeding value for growing-finishing swine. *J. Anim. Sci.* 53:138.
- Krider, J.L., B.W. Fairbanks, R.F. Van Poucke, D.E. Becker and W.E. Carroll. 1946. Sardine condensed fish solubles and rye pasture for sows during gestation and lactation. *J. Anim. Sci.* 5:256.
- Leibbrandt, V.D. 1977. Performance by gestating swine self-fed a diet containing ground peanut hulls. *Fla. Agr. Exp. Sta. Res. Report* MA-1977-3.
- Lehninger, A.L. 1982. Principles of Biochemistry. Worth Publishers, Inc., New York, NY.
- Lindemann, M.D., E.T. Kornegay and R.J. Moore. 1986. Digestibility and feeding value of peanut hulls for swine. *J. Anim. Sci.* 62:412.
- Linzell, J.L., T.B. Mephram, E.F. Annison and C.E. West. 1969. Mammary metabolism in lactating sows: Arteriovenous differences in milk precursors and the mammary metabolism of (^{14}C) glucose and (^{14}C) acetate. *Br. J. Nutr.* 23:319.

- Lellis, W.A. and V.C. Speer. 1983. Nutrient balance of lactating sows fed supplemental tallow. *J. Anim. Sci.* 56:1334.
- March, B.E. 1979. The host and its microflora: An ecological unit. *J. Anim. Sci.* 49:857.
- Marier, J.R. and M. Boulet. 1959. Direct analysis of lactose in milk and serum. *J. Dairy Sci.* 42:1390.
- Maynard, L.A., J.K. Loosli, H.F. Hintz and R.G. Warner. 1979. *Animal Nutrition*. McGraw-Hill, New York, NY.
- Mitchell, H.W., W.E. Carroll, T.S. Hamilton and G.E. Hunt. 1931. Food requirements of pregnancy in swine. *Ill. Agr. Exp. Sta. Bull.* 375.
- Moore, R.J., E.T. Kornegay, R.L. Grayson and M.D. Lindemann. 1988. Growth, nutrient utilization and intestinal morphology of pigs fed high-fiber diets. *J. Anim. Sci.* 66:1570.
- Moser, R.L., E.R. Peo, Jr., B.D. Moser and A.J. Lewis. 1982. Effect of grain source and dietary level of oat hulls on phosphorus and calcium utilization in the growing pig. *J. Anim. Sci.* 54:800.
- National Academy of Sciences (NAS). 1971. *Atlas of nutritional data on United States and Canadian Feeds*. Washington, DC.
- National Research Council (NRC). 1979. *Nutrient requirements of domestic animals, No. 2 Nutrient requirements for swine, Eighth Revised Ed.* National Academy of Science - National Research Council, Washington, DC.
- NCR-42 Committee on swine nutrition. 1978. Effect of protein level during gestation and lactation on reproductive performance in swine. *J. Anim. Sci.* 46:1673.
- Noblet, J., J.Y. Dourmad and M. Etienne. 1990. Energy utilization in pregnant and lactating sows: Modeling of energy requirements. *J. Anim. Sci.* 68:562.
- Noblet, J. and M. Etienne. 1986. Effect of energy level in lactating sows on yield and composition of milk and nutrient balance of piglets. *J. Anim. Sci.* 63:1888.
- Nuzback, L.J., D.S. Pollmann and K.C. Behnke. 1984. Effect of particle size and physical form of sun-cured alfalfa on digestibility for gravid swine. *J. Anim. Sci.* 58:378.

- Okai, D.B., F.X. Aherne and R.T. Hardin. 1977. Effects of sow nutrition in late gestation on the body composition and survival of the neonatal pig. *Can. J. Anim. Sci.* 57:439.
- Otero, J.R. 1952. Informacoes sobre algumas plantas forrageiras. Servicos de Informacoes Agricola do Minist. de Agricultura, de Janeiro, Brasil. Ser. Didatica No. 11. 179 p.
- Partridge, I.G. 1982. The utilization of dietary fibre by pigs and other non-ruminants. *Proc. 38th Fla. Nutr. Conf., St. Petersburg, FL.*
- Pettigrew, J.E. 1981. Supplemental dietary fat for periparturient sows: A review. *J. Anim. Sci.* 53:107.
- Pollmann, D.S., D.M. Danielson, M.A. Crenshaw and E.R. Peo, Jr. 1980. Long-term effects of dietary additions of alfalfa and tallow on sow reproductive performance. *J. Anim. Sci.* 51:294.
- Pollmann, D.S., D.M. Danielson and E.R. Peo, Jr. 1979. Value of high fiber diets for gravid swine. *J. Anim. Sci.* 48:1385.
- Pollmann, D.S., S.M. Dennis and R.R. LaForge. 1983. Influence of alfalfa addition to sow diets. *Kansas State University, Report of Progress No. 442, p. 12.*
- Pond, W.G. 1987. Thoughts on fiber utilization in swine. *J. Anim. Sci.* 65:497.
- Pond, W.G. and J.H. Maner. 1984. *Swine production and nutrition.* AVI Publishing Company, Inc., Westport, CT.
- Pond, W.G., K.R. Pond, W.C. Ellis and J.H. Matis. 1986a. Markers for estimating digesta flow in pigs and the effects of dietary fiber. *J. Anim. Sci.* 63:1140.
- Pond, W.G., V.H. Varel, J.S. Dickson and W.M. Haschek. 1989. Comparative response of swine and rats to high-fiber or high-protein diets. *J. Anim. Sci.* 67:716.
- Pond, W.G., J.T. Yen, R.N. Lindvall and D. Hill. 1981. Dietary alfalfa meal for genetically obese and lean growing pigs: Effect of body weight gain and on carcass and gastrointestinal tract measurements and blood metabolites. *J. Anim. Sci.* 51:367.

- Pond, W.G., J.T. Yen and V.H. Varel. 1985. Effects of level and source of dietary fiber in gestation on reproductive performance and nutrient digestibility in gilts. *Nutr. Rep. Int.* 32:505.
- Pond, W.G., J.T. Yen and V.H. Varel. 1986b. Effect of alfalfa meal on growth, reproduction, and nutrient digestibility in swine. *Swine Res. Prog. Rep. N. 2* USDA, ARS-54, p. 52.
- Powley, J.S., P.R. Cheeke, D.C. England, T.P. Davidson and W.H. Kennick. 1981. Performance of growing-finishing swine fed high levels of alfalfa meal: Effects of alfalfa level, dietary additives and antibiotics. *J. Anim. Sci.* 53:308.
- Prine, G.M. 1964. Forage possibilities in the genus *Arachis*. *Soil and Crop Sci. Soc. of Florida Proc.* 24:187.
- Prine, G.M. 1972. Perennial peanut for forage. *Soil and Crop Sci. Soc. of Florida Proc.* 32:33.
- Prine, G.M. 1980. Growing perennial peanuts for rhizomes. Univ. of Florida, IFAS, Agr. Res. Rep. AY-80-6.
- Prine, G.M., L.S. Dunavin, R.J. Glennon and R.D. Roush. 1986. Arbrook Rhizoma Peanut. A perennial forage legume. Circular S-332. Agricultural Experiment Station. IFAS, University of Florida, Gainesville.
- Prine, G.M., L.S. Dunavin, J.E. Moore and R.D. Roush. 1981. 'Florigraze' Rhizoma Peanut. A Perennial Forage Legume. Circular S-275. Agricultural Experiment Stations. IFAS, University of Florida, Gainesville.
- Randall, G.C.B. 1982. Changes in fetal and maternal blood at the end of pregnancy and during parturition in the pig. *Vet. Res.* 32:278.
- Ranvindran, V., E.T. Kornegay and K.E. Webb, Jr. 1984. Effects of fiber and virginiamycin on nutrient absorption, nutrient retention and rate of passage in growing swine. *J. Anim. Sci.* 59:400.
- Rerat, A. 1978. Digestion and absorption of carbohydrates and nitrogenous matters in the hindgut of the omnivorous nonruminant animal. *J. Anim. Sci.* 46:1808.

- Rerat, A., M. Fiszlewicz, A. Giusi and P. Vaugelade. 1987. Influence of meal frequency on postprandial variations in the production and absorption of volatile fatty acids in the digestive tract of conscious pigs. *J. Anim. Sci.* 64:448.
- Robertson, J.B. and P.J. Van Soest. 1977. Dietary fiber estimation in concentrate feedstuffs. *J. Anim. Sci.* 45(Suppl. 1):254.
- Romero, F., H.H. Van Horn, G.M. Prine and E.C. French. 1987. Effect of cutting interval upon yield, composition, and digestibility of Florida 77 alfalfa and Florigraze rhizoma peaunt. *J. Anim. Sci.* 65:786.
- Scheunert, A. 1906. Hoppe Seyler's Ztschr. *Physiol. Chem.* 48:9. Cited by P.D. Cranwell. 1968. Microbial fermentation in the alimentary tract of the pig. *Nutr. Abstr. Rev.* 38:721.
- Schneider, B.H. and W.P. Flatt. 1975. The evaluation of feeds through digestibility experiments. The University of Georgia Press, Athens, GA.
- Schoenherr, W.D., T.S. Stahly and G.L. Cromwell. 1989a. The effects of dietary fat or fiber addition on energy and nitrogen digestibility in lactating, primiparous sows housed in a warm or hot environment. *J. Anim. Sci.* 67:473.
- Schoenherr, W.D., T.S. Stahly and G.L. Cromwell. 1989b. The effects of dietary fat or fiber addition on yield and composition of milk from sows housed in a warm or hot environment. *J. Anim. Sci.* 67:482.
- Seerley, R.W. and R.C. Wahlstrom. 1965. Dehydrated alfalfa meal in rations for confined brood sows. *J. Anim. Sci.* 24:448.
- Sherry, P.A., P.C. Harrison and G.C. Fahey, Jr. 1981. Dietary fiber and antibiotic interactions on nutritional and metabolic parameters in the growing pig. *J. Anim. Sci.* 53:1309.
- Shurson, G.C., M.G. Hogberg, N. DeFever, S.V. Radecki and E.R. Miller. 1986. Effects of adding fat to the sow lactation diet on lactation and rebreeding performance. *J. Anim. Sci.* 62:672.
- Spincer, J., J.A.F. Rook and K.G. Towers. 1969. The uptake of plasma constituents by the mammary gland of the sow. *Biochem. J.* 111:727.

- Stahly, T.S., G.L. Cromwell and W.S. Simpson. 1981. Effects of level and source of supplemental fat in the lactation diet of sows on the performance of pigs from birth to market weight. *J. Anim. Sci.* 51:352.
- Stanton, H.C. and J.K. Carroll. 1974. Potential mechanisms responsible for prenatal and perinatal mortality or low viability of swine. *J. Anim. Sci.* 38:1037.
- Steel, R.G.D. and J.H. Torrie. 1980. Principles and procedures of statistics (2nd Ed.). McGraw-Hill Book Co., Inc. New York.
- Swenson, M.J. 1978. Composition of body fluids. In: H.W. Dunne and A.D. Leman (Eds.) Diseases of swine. Iowa State University Press, Ames, IA.
- Teague, H.S. 1955. The influence of alfalfa on ovulation rate and other reproductive phenomena in gilts. *J. Anim. Sci.* 14:621.
- Terrill, S.W., D.E. Becker, R.M. Edwards and M.C. Nesheim. 1953. Ladino clover pasture and grass-legume silage for bred gilts and sows. *J. Anim. Sci.* 12:941 (Abstr.).
- Tyrrell, H.F. 1980. Limits to milk production efficiency by dairy cows. *J. Anim. Sci.* 51:1441.
- Van Soest, P.J. 1964. Symposium on nutrition and forage and pastures: New chemical procedures for evaluating forages. *J. Anim. Sci.* 28:838.
- Van Soest, P.J. 1967. Development of a comprehensive system of feed analysis and its application to forages. *J. Anim. Sci.* 26:119.
- Van Soest, P.J. 1975. Physico-chemical aspects of fiber digestion. In: I.W. McDonald and A.C.I. Warner (Eds.) Digestion and Metabolism in the Ruminant. Univ. of New England Publ. Unit, Armidale, Australia. 365 p.
- Van Soest, P.J. 1983. Nutritional ecology of the ruminant. O and B Books, Inc., Corvallis, OR.
- Van Soest, P.J. 1984. Estimating digestibility of ruminant feeds. *Feed Management* 35:29.
- Varel, V.H. 1987. Activity of fiber-degrading micro-organisms in the pigs large intestine. *J. Anim. Sci.* 65:488.

- Varel, V.H., H.G. Jung and W.G. Pond. 1988. Effects of dietary fiber of young adult genetically lean, obese and contemporary pigs: Rate of passage, digestibility and microbiological data. *J. Anim. Sci.* 66:707.
- Varel, V.H. and W.G. Pond. 1985. Enumeration and activity of cellulolytic bacteria from gestating swine fed various levels of dietary fiber. *Appl. Environ. Microbiol.* 49:858.
- Varel, V.H., W.G. Pond and J.T. Yen. 1984. Influence of dietary fiber on the performance and cellulase activity of growing-finishing swine. *J. Anim. Sci.* 59:388.
- Wahlstrom, R.C. and G.W. Libal. 1977. Effect of dietary protein during growth and gestation on development and reproductive performance of gilts. *J. Anim. Sci.* 45:94.
- White, C.E. and D.R. Campbell. 1984. Effect of dietary carbohydrate source on sow lactation performance and growth of nursing pigs. *Nutr. Rep. Int.* 29:579.
- White, C.E., H.H. Head, K.C. Bachman and F.W. Bazer. 1984. Yield and composition of milk and weight gain of nursing pigs from sows fed diets containing fructose or dextrose. *J. Anim. Sci.* 59:141.
- Wiley, J.R. 1919. How to grow and use forage crops for hogs. *Purdue Univ. Dept. Agr. Ext. Bull.* 66.
- Yen, J.T. and J. Killefer. 1987. A method for chronically quantifying net absorption of nutrients and gut metabolites into hepatic portal vein in conscious swine. *J. Anim. Sci.* 64:923.
- Young, L.G. and G.L. King. 1981. Wheat shorts in diets of gestating swine. *J. Anim. Sci.* 52:551.
- Zoiopoulos, P.E., P.R. English and J.H. Topps. 1983. A note of intake and digestibility of a fibrous diet self fed to primiparous sows. *Anim. Prod.* 37:153.

BIOGRAPHICAL SKETCH

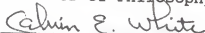
Fred Douglas Lopez, son of Carmen Sales de Lopez and Vicente Lopez, was born in Chalatenango, El Salvador, on January 19, 1957.

He graduated from the National High School of El Salvador, in 1975. From May, 1977 to March, 1980 he attended the National School of Agriculture of El Salvador, La Libertad, and received the Agronomo degree.

He has attended the University of Florida since the Spring of 1981 where he was awarded a Bachelor of Science degree in 1983 and a Master of Agriculture degree in 1985. He is currently a Ph.D. candidate in animal science with a specialization in swine nutrition, under the guidance of Dr. C.E. White.

He is a member of the Gamma Sigma Delta Honor Society for Agriculture. He is married to Blanca Luz Lopez and they have three daughters, Carla Maria, Gabriela and Daniela Nicole.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.



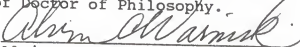
Calvin E. White, Chairman
Associate Professor of Animal
Science

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Joseph H. Conrad
Professor of Animal Science

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.



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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.



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This dissertation was submitted to the Graduate Faculty of the College of Agriculture and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December, 1990

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